PSYCHOLOGY: A NEW SYSTEM

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PSYCHOLOGY

A NEW SYSTEM

BASED ON THE STUDY OF THE FUNDAMENTAL PROCESSES OF THE HUMAN MIND

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VOL. II

MCMXII

STEPHEN SWIFT AND CO LTD

NUMBER SIXTEEN KING STREET

COVENT GARDEN

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BOOK II *(Continued)*

PART I

CHAPTER II

§ I. QUESTIONS OF RESEARCH

HITHERTO we have dealt with cases of reasoning where a certain problem has been posed for solution; and we have considered the progress of the mind in tracing out solutions already obtained, and we have indicated the nature of tentative efforts tending to obtain such solutions.

We may now proceed to study processes of Reason where the problem itself is not given but where the mind sets out to discover new facts, or new relations, in a field of science.

A complete and satisfactory exposition of such processes would constitute a system of Research; but it seems at present impossible to formulate such a scheme. Nevertheless in examining the matter in various fields we find that in certain of these we may say beforehand that useful results may be obtained by proceeding according to ascertainable principles.

Thus if a naturalist set himself the task of observing the habits of the ornithorhyncus, which is an amphibious animal, he might be assured that for that reason alone he would make interesting discoveries. He might have

been led to settle the question as to whether the ornithorhyncus is oviparous or viviparous; and that question was at a certain epoch of special moment to biological science.

The old anatomists who had begun to distrust Galen were sure of making discoveries of importance in their dissection of the human body, for the field itself was of great interest, and the observations had hitherto been often erroneous or not sufficiently precise. Thus it happened that when van Graaf discovered the thoracic duct he paused long before he opened it with his knife, feeling that he was on the point of a discovery of prime importance.

Darwin in setting out on his Voyage of the *Beagle* had not formulated his problems, but he knew that discoveries lay in his path. Even in meeting with coral reefs it was not till after some preliminary considerations and researches of the nature of seeking experiences that the problems presented themselves in more or less clear form.

The medical expert whose duty it is to examine a body in a case of suspected murder makes observations of many kinds before the crucial questions arise, as, for example, at what distance a gun was fired that caused a wound in the head.

Or we may propose to examine Kant's "Kritik der Reinen Vernúnft" in order to test the rigour of the reasoning; or the problem may be presented as to the genesis of the characteristic notions.

If one set forth on a study of the Scottish Philosophers of the Eighteenth Century, one may be sure at least of finding material for a weighty book; but if a man throw off authority in the style of Descartes he may not know at first even whither his thoughts will be led. Or if he search in the nature of things for the data of Ethics

he may experience much uncertainty how to pose his problems. He may be shaken by still greater incertitudes if, regarding the scope of the sciences, he does not select any thesis for examination, but asks the questions from his place in the Universe: What is the problem that I shall attempt? How shall I know the source of my own impulses, my thoughts, my joys, my sorrows?

When we consider the manner of gaining experience of the external world by Immediate Presentation, we recognise not only the limitations of our species, as being restricted to a scope of sensation, for example, which corresponds but to a small part of the scale of the external forces; but we also recognise in each individual that the scope of his possibilities is marked by his personal characteristics. But the sum-total of knowledge, and the operations of Reason, are influenced likewise by the factors of heredity of the individual and the whole of his previous stored-up knowledge.

We have seen also the part played even in what are considered purely intellectual matters by the emotional factors. We have seen that not only in striking out a course of life, but in dealing with arguments that come to us in a purely intellectual appearance, moral qualities are of great importance, qualities not only of sincerity but of courage.

Among those matters to be taken into account in regard to the question of Research are those also of the degree of complexity of the subject under consideration and the grade of development which the investigating mind has attained.

Even a theme of social science like that of Adam Smith's great work, "The Wealth of Nations," though requiring fine faculties of analysis, is yet more circumscribed and determined than such studies as those relating to the influence on development of races of those geographical

upheavals and divisions of the earth's surface which Elie de Beaumont indicated in magnificent generalisations.

The studies of Robert Brown in Botany, collating a vast number of facts as a result of careful observation, are yet on a plane of more obvious tasks than those of Darwin on the Origin of Species.

The observations of diseases by the old physicians, though often acute, are certainly more superficial than the researches of Pasteur, following the indications of Schwann, into the cause of anthrax, which he finally traced to a certain bacillus. The researches of Ross into malarial fever, Manson into diseases produced by filaria, and Laveran into yellow fever dealt with problems having aspects still more elusive to direct observation, for they had to trace out the hidden mode of conveyance of the infection by mosquitoes.

The observations of the geology of a neighbourhood present problems more direct and tangible than that which Copernicus encountered when, after tracing and attempting to apply the complicated system of Ptolemy, his mind rose to the great conception of the solar system with the earth and the other planets revolving round the sun. The task which Kepler set himself, namely, that of ascertaining the orbits of the planets, though extraordinarily intricate and demanding a wonderful combination of the genius of insight and of patience for its solution, is yet after all more definite at least in its enunciation.

The problem of Universal Gravitation, again, was posed already before Newton, but it is the glory of the great author of the "Principia" to have divined the law and with masterly skill to have exhibited the demonstration. The nebular hypothesis of Kant, afterwards elaborated by Laplace, forms, even though the theory be not established, a rare leap of intellect beyond the realm of mere observation.

In examining the origin of great discoveries, and the course of the development of all that prepared the way, and followed from them, we may be led to find some general principles of guidance. One of the chief requirements is that of accuracy in regard to observations, and the record of observations. We may profitably read at this day an account of an epidemic of mumps recorded by Hippocrates as raging amongst Greek soldiers of an expeditionary force, for Hippocrates was a very careful observer. The writings of the physicians of Louis XIV., on the other hand, are absurd, for they substituted theories for observation and their theories had no valid foundation.[1] Correct observation does not imply a mere colourless record, for the number of things capable of being recorded is infinite. Observation should be distinguished by discrimination, by the endeavour to seize the essential and to neglect the accidental.

With the number of facts accumulated it will be necessary to adopt some system of classification. We have already seen in what way this easily becomes necessary with regard to Memory and its associations (cf. p. 88, p. 140, and p. 236).

A principle of classification must be sought that corresponds as far as possible to active, constant operations in the world, as, for instance, those that we call cause and effect (see pp. 8, 9, 11, 330). This implies the greatest security of sequence, and hence the greatest facility of associations. De Candolle's classification in Botany improved on that of Linnæus by its corresponding more nearly to the vital functions of the organisms.

[1] Recently in reading a report of Byron's last illness with reference to the medical side, I discovered that "the inflammatory diathesis changed to the lymphatic." Thereupon the poet was bled again and again. Such a hotch-potch of nonsense as contented generations of scientific men would be laughable, except that it generally, as in Byron's case, conduced to the death of the patient.

Darwin's theories of Evolution, to which Herbert Spencer gave more precise expression, have throughout the vegetable and animal world given new standards, because they express a profound conformity with the processes of nature. Herbert Spencer's theory of Evolution may indeed be looked on simply as a formula of classification, involving principles of division which, however, are not always consistent, nor clearly determined.

Generalisation is necessarily implied in classification. A generalisation may be a record of common features of a class exhibiting diversities in the individuals. Thus, for example, there are certain general features common to all fevers; such as malaise, high temperature, increased pulse rate. Each kind of fever has its special features.

Or again generalisation may involve assumptions which may or may not be true. When having observed that no man has lived beyond a certain age we say that all men are mortal, we generalise by making an assumption which is no doubt true. But if we say all Norsemen have blue eyes we make an assumption which is not borne out by facts.

Practically generalisation involves more than the recognition of community in a group that also shows divergences. It involves assumptions, and this, though a source of error, has also been a fruitful source of the progress of human knowledge (cf. p. 332). Thus Newton, finding that a certain law of attraction explains the movements of the moon about the earth, propounds a law of Universal Gravitation. Now we have not tested this law in relatively many instances. The generalisation contains therefore an assumption which is possibly not universally true.

Again, the young German student, Schwann, in a few simple experiments laid the foundation for the develop-

ment of the science of bacteriology, and therefore the basis of the progress of modern medicine (cf. p. 333). Roughly stated his experiments were these: He placed some pieces of meat in jars, which he sealed hermetically. No putrefaction took place. He then admitted the air. Putrefaction began.

Now the notion of microscopical organisms being found in the air was familiar to Schwann, as it was to other scientists before him. Excluding other causes, he therefore propounded the theory that the putrefaction was due to access to the meat having been permitted to these microscopical organisms or "germs." But as putrefaction is only an example of organic change, and as Schwann's mind had been occupied with other instances of organic changes, especially fermentation, he gave to his theory the extraordinarily bold but happy generalisation that in all organic change the agency of such germs is necessary. Here then was a theory having a direct practical bearing on a thousand processes in the external world, physiological and pathological, in our own bodies.

Pasteur's researches gave such an impulse to the study of fermentations, and of diseases, in the light of this theory that they overshadowed the original work of Schwann. The actual discovery of "microbes" in tissues affected by disease, such as cholera, gave strong support to Schwann's theory. The criteria which Koch laid down for ascertaining whether a disease was due to a certain microbe, and which in some cases were shown to be fulfilled, might be thought to have confirmed Schwann's theory.

Yet that theory involved great assumptions, and, it seems, important unwarranted assumptions. For there was nothing in his experiments to exclude this possibility, that the organic changes did not absolutely require the presence of the germs, but of certain sub-

stances and ferments, for example, produced by the germs.

Meanwhile the assumption had been of incalculable value in developing a great field of science. It will be seen, moreover, that all operations of Reasoning have a character analogous to this mode of progress.

Again, if we generalise by saying that the atomic weights of elements are formed in regular gradations according to Mendelejeff's scale, it cannot be said for certain that we are right or wrong. Even wrong generalisations have been helpful in the cause of science. The discovery of their error renders our Discrimination more precise. Bold assumptions put forward as generalisations which have afterwards been found to be correct have been at times a stimulus and a guide to discovery. Mendelejeff's scale, for example, by pointing out that elements were still required to complete the gradations, suggested experiments which led to Prof. Ramsay's discovery of argon and other elements.

It must always be borne in mind that Reason proceeds by means of a continual interaction between the new experiences coming to us from the external world and the whole of our previous knowledge stored up, marked by symbols, characterised by all manner of Associations and Impulses.

Classification will be found accordingly to have influence on the order of our thought in more than one way. Classification is necessary to avoid confusion in reference (cf. pp. 140, 236, 340, 383) and also for the purpose of Memory (cf. pp. 140, 303, 342, 383). But also classification will be found to have a deep correspondence with external reality. The whole course of scientific discovery has been in a direction towards simplification by classification. We note a number of separate phenomena; subsequently we discover a certain

"law" of Nature which explains the phenomena in such a way that we can predict their occurrence. Some of the most highly general laws, such as that of Universal Gravitation, have been found expressible in simple formulæ, but it must be understood that these formulæ refer to the sequences of phenomena, not to the essential character of the forces influencing them. We say that each particle in the universe attracts each other particle with a force which is great in proportion to its mass, but in proportion inversely to the square of its distance. But the "law" tells us nothing of the cause of the attraction. Indeed, many physicists find that herein we are presented with a notion inconceivable on the basis of our previous experience—the notion of force acting at a distance. Clearer views may be obtained by more closely investigating the meaning to be attached to the word "force," but this discussion lies beyond our present object.[1]

It must be understood also that the term "law" means nothing further than a compact expression regarding phenomena as manifested to our experience. Consequently as our own minds, on account of their limitations in the immediate comprehension of ideas, move by classifications indicated by symbolisation, certain of these forms of groupings that we ascribe to the external world have meaning only with reference to the mode of our intelligence (cf. pp. 54, 141, 191, 236, 340, 383).

Nevertheless there appear to be in nature innumerable categories of things of which the developments are formed by variations upon general plans. Thus in animal life we find, since there must be waste, and consequently repair of material, some apparatus for

[1] See the conclusion of Prof. Tait's article on Mechanics in the "Encyclopædia Britannica"; also the writings of Clerk Maxwell, Poincaré, and Lord Kelvin.

conveying material to and from the parts. This involves some kind of circulatory apparatus. The material thus conveyed, not being found ready prepared, must be prepared from various substances containing unnecessary adjuncts. Hence some kind of digestive apparatus is involved. The movements implied by these operations, and also other movements without which life seems incompatible, must be determined by stimuli from the outside world, and within the organism itself. Hence we have the analogues of what in a more developed form we recognise as the muscular and nervous systems. But upon this plan, which in the manner in which we express it is relatively simple, endless varieties have been wrought.

And this example is offered only as an illustration of the fact that things are so ordered in the external world that generalisations and classification, if well chosen, not only represent known correspondences with the internal world but lead to discoveries of new correspondences consistent with them. Consequently a habit of persistent generalisation and classification is of the utmost importance in Reason.

The whole course of science and the whole scope of Reason may be set forth as that of ultimately finding relations of Agreement. The final expression of laws are not negative, but positive statements. Even when Discrimination acts as in the way of Disassociation, we find at length a definite positive expression to mark the case so obtained. Thus in our course of life we meet with beans as edible food. Then subsequently we become acquainted with the Calabar bean. Experience proves that this contains poison. Closer attention is paid to its characteristics, and from a study of these the Calabar bean is known and classified. At length we discover its advantages in medicine, and this association overrides that of its negative characteristics.

Certainly owing to our incomplete means of knowledge we must in our progress in the world of thought continually make use of safeguards, limitations, restrictions, but the tendency of these eventually is to guide us to positive associations having an outcome in exercise and use.

But the bases of agreements are often hidden beneath diverse appearances that in Immediate Presentation seem at first dominant.

To examine directly point by point all the discrepancies in the multitude of objects in the external world would be impossible, even if only on account of the time involved. But following the scheme of a classification we find that if under each heading we have only two objects, separated by some good principle of division, and under each of these two others, and so on, then with relatively very few applications of this principle of division we classify an immense number of objects.

This is seen in the familiar game where anything in the world may be selected for guessing. Those who guess are allowed to ask, Is it in the organic or the inorganic world? Is it an animal, or a vegetable? Is it a mammal? and so on. After a few questions posed and answered any object selected from the world may be determined.

Thus the value of classification in our modes of Reason is of importance, in the first place because diversities based upon agreements prevail so largely in the world of our experience, and secondly because in this way of classification it is possible for us to define, and thence form associations with, a vast number of objects of which otherwise the discrepancies would bewilder our minds.

What we call "laws of Nature" are the expressions of certain of these most profound agreements.

In the consideration of errors of reasoning we were led especially to notice Discrimination, Generalisation, classification, symbolisation, Memory, Association, though remarking that these processes must imply the others (cf. pp. 35, 36). But it is with regard to the whole complex of our stored-up knowledge that these processes become evident in their association with the new Immediate Presentations continually brought in by experience.

Hence for the purpose of exposition we may lay special stress on these processes in regard to building up a scientific habit of thought.

Darwin, for example, took the faculty of generalisation to be the mark of a scientific mind. And by generalisation we mean the discovery of resemblances amid accidental differences. And in dealing with complex matters these resemblances must be sought not on superficial grounds, but on some vital principle, something such as the relation of cause and effect, that strikes deep into the constant order of the Universe. Classification in accordance with this form of generalisation enables a great complex to be held together, and progress is made as already noted, even in cases of wrong original generalisation and classification.

Even such a quality as persistence, which might be thought to appertain rather to the emotional and moral side of men's nature, has become necessarily implied in the habit of deep generalisations, for the mind forms its associations around the things shown to have a common factor through our generalisation, and new problems, new discoveries of resemblance, of cause and effect, new generalisations are evolved (cf. pp. 53, 328). And since, as we have observed, Nature builds continually on similar plans, it is impossible to formulate any deep truth without afterwards discovering applications

which may not have appeared at first within the range of that speculation.

Considerations of this kind led Darwin, Herbert Spencer, and others of that school of pronounced scientific cast of mind, to hold in small esteem the character of Carlyle's thought, even though he was to the general public pre-eminently a "thinker"; for with remarkably luminous flashes of insight, there was lacking in Carlyle the features of systematic work by means of analysis, with the expression in generalisation and classification; and with all his tenacity and perseverance in regard to his own tasks, there was no persistency of thought along definite lines with expression in a cohesive sequential style.

Another reason why the habit of generalisation and classification is so important is that by reason of the discipline of the mind it involves it enables the thinker to wield his apparatus of analysis with mastery. Consequently if he makes one discovery he is almost certain to make other discoveries by reason of what we have seen of the great diversities of things of Nature formed on similar plans.

Thus Newton had formed the basis of his life's work in reducing to simple expressions the principles of Mechanics. In the subsequent application of his system his mind was long occupied on questions of attractions, and, in accordance with his own third law of motion, of repulsions.

His discovery of the law of Gravitation had not only immersed his mind in a multitude of associations round the thesis of attraction, but had given him great skill in the handling of the mathematical apparatus involved in the calculations. When therefore Newton turned his attention to the study of light he sought to explain all the phenomena by means of attraction and repulsion

of material corpuscles. And when Newton examined the problem of the tides it was always with the same notion of attraction and repulsion, and with applications of the same mathematical apparatus.

It is interesting to compare with Newton's system that of Thomas Young. For Young, having adopted and expounded the undulatory theory of light, not only discovered some highly interesting facts regarding light itself, but also acquired a great facility in the use of the calculus corresponding. Thus also he formed associations with this theory in fields in which it would seem to others hardly applicable. Turning his attention to the theory of tides, he showed the influence not merely of the attractions actually subsisting at the moment of observation, but of the previous effect of attractions persisting in their influence on marine currents and undulations.

Another of Young's activities having no immediate relation to indulations, though connected with the study of light, was that referring to the formation of colours from the primary colours red, blue, yellow. During a tour on the Continent he became interested in the pictures of the great masters, and he set forth certain canons of criticism founded on the relative frequency of use of these colours. In this way it would be possible to test the authenticity of a picture.[1]

The same associations of ideas led Young subsequently to set forth a theory of colours founded on the cardinal colours.

[1] This notion might be pursued further. We might by examining narrowly the predilections of poets for certain colours, form for each poet a spectrum of colours which would be quite characteristic. A beginning has already been offered in "A Study of the Sense Epithets of Shelley and Keats" by Mary Grace Caldwell (*Am. Journ. of Psych.* 1898). She finds that both poets speak of blue, green, white, and gold more than of red. Per line, Keats uses more sense words than Shelley; Shelley uses colour words with greater frequency.

Again, the old school of physicians made many observations in diseases which were true within their scope, and which had so many applications that they thought they had discovered the whole truth. But when Schwann, and later Pasteur, and Koch, and all the bacteriologists who followed, developed the "germ theory," then microbes were found so universally, their manifestation seemed so plain and striking, that the wonder became how they had been ignored for so long. Koch guessed that the "going-bad" of a potato was due to the action of microbes, and by this discovery showed the way to the "culture" of microbes, and so enormously advanced the science of bacteriology.

Bacteria have been shown to be the purifiers of detritus, and also to be agents in the fertilisation of lands otherwise condemned to sterility (cf. *Bacillus radici-cola*, studied by Prof. Bottomley). And certain investigators, unduly pressing the themes of M. Metchnikoff, have searched for the microbe of old age.

When electricity began to reveal its marvels Schelling cried out: "All is electricity! All is electricity." At a still earlier epoch mathematics were thought to be the gate to all knowledge.[1] And, at a later period, when investigations of biology in the hands of great workers began to throw light on problems not immediately connected with that branch of study, it became assumed that biology held the key of all teaching.[2] So in this way we have seen in history a succession of veritable fashions in science.

[1] Mathematics, now too often regarded as a chilly and repellent subject, once formed the delight even of ladies of the court. Sophie Charlotte, in one of her letters, speaks of Leibnitz talking to her of the Calculus, "as if any one could teach *me*, the wife of the Elector, anything about the Infinitely Little!"

[2] Binet (*l'Année Psych.*, 1906) derided Haeckel for his display of biological learning in dealing with subjects only remotely connected with these specialised studies.

The underlying reason has been that the objective realities corresponding cover wider spaces than those into which we have dipped the plummet of our research.

The discussion of the scientific use of imagination, on which Tyndall wrote a luminous chapter, has to do with a similar order of ideas. Imagination used in this sense is the discovery, through a mass of accidentals, of fundamental resemblances either of experience or construction.[1]

The work of Copernicus in disassociating from his mind all appearances due to the most striking Immediate Presentations, viz. those of the rising of the sun, in order to conceive the true solar system, is a triumph of imagination. In this case it is an imagination of construction, for erecting in his mind a symbolic representation of the solar system is as far as he knew it, it became easier to imagine the manner of movement.

The brilliant theory worked at by Mijnheer van t'Hoff and Sir J. Thomson, of the atom being a minuscule system, comparable to the solar system, is another triumph of constructive imagination.

The notion of heat being a form of energy, although it is now familiar to us, has always seemed to me to be due to a subtle feat of scientific imagination. Certainly we have, as in the case of boring a cannon which drew the attention of Rumford to it, the association of mechanical work with heat; but it required preliminary deep thought on the essential nature of things to see the community in diverse manifestations of energy.

Yet men's minds had evidently been prepared, by a course of science fraught with propitious associations,

[1] L. Arréat has written on "Mémoire et Imagination," 1895; and Pierre Boutroux on "l'Imagination et les Mathématiques"; and Adam (cf. *Rev. Phil.* 1890) on "l'Imagination dans les Découvertes scientifiques." George Gore's "History of Discovery" is full of interest from this standpoint, and G. Wilson's "Religio Chemici" fascinating.

for the acceptance of this doctrine, for there seems to be a doubt as to whom to ascribe its clear enunciation. Rumford seems to have been struck with it on the basis of independent thought and observation. Gay-Lussac had the same notion. So had Sir Humphry Davy.[1]

Sir Humphry Davy represents indeed the faculty of scientific imagination in quite a special way, for in order to excite his imaginative faculties he used to attend Coleridge's lectures on poetry. We shall see a little later an explanation of such an aid to discovery.

The theory of heat as a mode of energy was afterwards extended in scope until finally, in the hands of great investigators of wide knowledge, of whom Helmholtz was a type, we find the essentials of the theory included in that of the doctrine of the conservation of energy. In this case, however, although the knowledge, the skill of exposition, the command of scientific instruments of research, implied vast scientific capacity, yet the actual theme itself had become less recondite than before that leap of genius which enabled us to regard heat as a mode of energy. For having in this instance demonstrated that energy is not lost but only transformed, it becomes suggested without great difficulty to pursue that inquiry into every instance of apparent loss of energy.

The case is similar to that which arises when we have a certain number of objects included in one classification. We form some association with one, such as the discovery of an unexpected peculiarity, then the natural Impulse connected with this association leads by further easy associations to examine each of the others in turn.

[1] The theory appears to have been first set forth by Huyghens, but the works of Lavoisier, Rumford, Laplace, Carnot, Gay-Lussac, and Davy especially gave the modern impulse to the study, afterwards continued brilliantly by Mayer, Helmholtz, Clausius, Clerk Maxwell, Raoult, and others.

The exclamation of Buffon, "There is only one animal," revealed a feat of imagination. For this, in the epigrammatic French style, expressed the theory that all animals have been developed by evolution from the primordial type. The whole work of Geoffroy St. Hilaire was conducted on this suggestion, and the theories he put forth in consequence and the conflicts that ensued with the more orthodox Cuvier fired in turn the imagination of the poet Goethe to new conceptions of the Universe.

Darwin's progress from the arguments of Malthus to the notion of the struggle for existence throughout all the organic world, and thence to the doctrine of Natural Selection, was marked by efforts of imagination beholding similarity in conditions having ostensibly great dissimilarity.

In a great many instances in the history of science some accident has afforded the stimulus to the necessary flash of imagination. Thus Forbes, while pondering on the problem of the movement of glaciers, was nearly tripped up by an old woman pouring out beans from a bag in front of him. The forcible associations thus produced between the observance of the manner of sliding of the beans and the object of his study gave him the necessary clue to movements of which he studied the applicability to the glaciers.[1]

Again, d'Orbigny, while studying volcanoes and being puzzled by certain problems as to the vaporisation of the water in caverns at a high temperature, stepped into a cottage where an old woman was ironing linen. Being fatigued, he sat down near the fireside. Presently he observed that to test the heat of the iron the old woman

[1] The sliding theory, however, had been advanced by de Saussure; and Forbes, having gone to Switzerland to decide between this theory and that of expansion, concluded that both were insufficient. He propounded a new theory, that of the viscosity of ice, and this is now generally accepted.

spat on it, and that the saliva slid off before it had time to evaporate. This suggested to his mind an experiment by which it may be shown that with water in a hot crucible a sort of film of water nearest to the hot surface becomes evaporated, and the steam being a bad conductor of heat retards the evaporation of the rest of the water.[1] This explanation made clear various matters in connection with the character of the violence of eruptions in volcanoes.

In these cases of accidental discovery the mind has already been prepared, as Pasteur pointed out, to grasp the full significance of the phenomena presented by accident. For indeed, we are constantly meeting with accidental phenomena which might reveal to us important secrets if we but knew how to interpret them. On the other hand, a mind completely engrossed in a subject, and intent on examining it from every point of view, and at the same time observing the multitude of phenomena that come within experience, is not unlikely to meet with such as throw illumination on the subject of study.

The mind in an operation of reasoning not being able inevitably to choose correct sequences, proceeds on a series of Impulses, forming associations, the relations of which to our previous knowledge are determined according to those principles of Reason which we have already discussed, those which are unsuitable being rejected. When the chain of reasoning is already formed, and simply submitted to examination, then the advantage is that the Impulses are

[1] This experiment is familiar at universities in the physical laboratories. I saw it performed in Berlin by Prof. Kundt, the successor of Helmholtz, with a skill that bordered on prestidigitation. The room was darkened, and he had projected on a screen the shadow of the drop of water floating above the surface of heated iron. The iron was allowed to cool, the drop came in contact with the surface. This completed the circuit for an electric bell which rang.

directed at once along the right path. In problems of a high degree of complexity we may, on the other hand, be carried by our Impulses producing associations along remote paths. We set forth propositions tentatively, and in the course of their solution we ascertain whether they represent validly conditions that prevail in the external world. In certain cases these propositions may be capable of graphic representation. For example, Kepler devised a great number of models destined to exhibit the course of the heavenly bodies before he arrived at the correct representation.[1]

Thus, both in the successive steps of a chain of reasoning and in the larger processes of posing problems and searching tentatively for paths leading to the discovery of new concordances in external nature, our progress is marked by a series of efforts, of which the false or unsuitable results are rejected. Using a physical illustration, we might say we Reason as we walk, by a series of fallings corrected (cf. pp. 332, 384, 386).

For guidance we depend to a great extent on acquired results. The time is past when a man, in the range of the physical sciences at least, can reasonably proceed, like Descartes, taking nothing for granted. To persist in that course would mean that science could never progress. On the other hand, we know that a vast amount of work has been done by great and careful observers, and that their results have been checked by the criticisms of hosts of minds, and that consequently we may accept the data so offered as the starting-points of new developments.

It is especially valuable to grasp thoroughly the

[1] Edison, before deciding in favour of the carbon filament for his electric light, had every quarter of the globe "ransacked" by his agents. See an article by G. A. Lathrop in *Harper's Magazine*.

leading principles of the sciences. For example, if a man propose to demonstrate a machine for perpetual motion we may save the time necessary for examining this in detail. We know that this proposal runs counter to the basic principle of the conservation of energy. In mathematics we may accept as insoluble such problems as squaring the circle. In fact Lindemann has shown that the problem is veritably insoluble by the use of finite series.

In each science the established principles become familiar, and the mind, moving in the field of experience, or theory, or experiment, becomes so continually guided by these principles that to another not versed in the science he seems to act by a kind of instinct. Thus it has been said that even the guesses of Newton are profound.

A mathematician may cast his eye over a complicated calculation and declare at once that a mistake has been made. This may be because he observes on one side of an equation a certain symmetrical relation of symbols, and on the other side a corresponding symmetry preserved in every term but one.

It must be noted, however, that in certain sciences, as in psychology, it is in the most fundamental phenomena that we must seek for guidance. Particularly every case is deserving of the closest attention where in a law ostensibly general there is met with some instance of exception.

Le Verrier and Adams independently established calculations destined to discover a planet whose influence would explain discrepancies between observed perturbations and the generality of the law of gravitation.[1]

The researches and careful estimations of Cavendish

[1] The planet discovered by means of Le Verrier's indications is that which bears the name Neptune.

in regard to the constitution of the atmosphere were not satisfied by the assumption that oxygen, nitrogen, and carbonic acid gas were the sole constituents. The discrepancies were subsequently neglected, being ascribed to errors of estimation, or simply forgotten. It was not until after the researches of Prof. Ramsay that attention was again called to the results set forth by Cavendish with entire correctness, though not with all the precision which improved methods rendered possible. Examples could be multiplied of valuable results being obtained by the examination of the obscure corners left in previous explorations.[1]

Accuracy of observation must be insisted upon. This is not quite the same thing as the desire of truth, for inaccuracy may arise from lack of Discrimination, and this may occasionally be due to a want of training in systematic habits, and particularly in the habit of classification (cf. pp. 345, 355, 368, 386, 389 *et seq.*).

Routh, the mathematician, having been asked for a characteristic phrase which would correspond to the important observations formed during his life, replied, "Verify your references." This points to accuracy not only in observation, but also in the application of symbols and in the acceptance of the associations implied.

Accuracy of observation and completeness of record have often been found of great importance in scientific discovery. They are, in fact, the guiding principle in the compilation of statistics, and the study of statistics has itself grown into a useful and fascinating science. We learn, for instance, that in a great city the number of suicides is fairly constant year by year, and that the maximum coincides rather with periods of depression in business than with climatic discomforts.

[1] Compare a remark to this effect in the Autobiography of John Stuart Mill. Gauss also lays emphasis on this point.

Such an observation helps our understanding of curious problems of sociology. Remarkable also is the theory put forth, capable of being tested only by statistics, that crimes of impulse are more common in months of high temperature.

Again, an eminent neurologist described part of his work as that of scientific book-keeping. For example, he was accustomed to examine every epileptic patient with particular care in regard to all questions of heredity, accompanying diseases, such as those of gout and heart disease, conditions of mental or physical stress, age, sex. After a great number of such cases had been examined the review of the records brought many curious points to light. Thus connection between epilepsy and gouty conditions occurred too frequently to be due to accidental coincidences.

We have already seen how it is explained that constant exercise in a field of study helps to make clear problems that have seemed at first complicated and obscure. Certain aspects of the problem become familiar, the energy required in reviewing them is less, the mind is left freer for observations, and Memory is rendered more facile in operation (cf. pp. 46, 140, 261, 344, 390).

By the fact of continual exercise along certain lines of thought the associations formed may lead to the mind being held within a certain field from which the suggestions of the solution cannot arise. Hence it has often happened in the history of research that the ideas leading to the solution have arisen at a time when the mind had ceased to be actively occupied with the problem. We have formed similar conditions with regard to Memory, which represents, however, only one feature of the present study (cf. pp. 239, 266).

M. Poincaré, the brilliant author of "Nouvelles

Méthodes de la Mécanique Céleste," relates in an essay on "Invention in Mathematics" that, having been greatly occupied with a problem that embodied new discoveries in the Higher Mathematics, he was in despair at a certain moment of ever finding a solution. Subsequently other duties called his attention away from the subject. One day when in the act of stepping into a coach he suddenly had a clear vision of the whole problem.

Here it was necessary for the mind to regain a condition of complete freedom before suggestions arose from other sources than those which had been persistently explored.

Thus the dictum of Newton that he had arrived at his discoveries by "always intending his mind" must be read also in the light of such experiences. The aphorismal expression of Graham, "Follow game," has a somewhat similar meaning. The question of "specialism" in science must also be examined in regard to this view of mental operations. The field of science still unexplored is so vast, and Nature is so diverse even in matters resting on similar principles, that persistent studies in limited fields of observation will almost invariably bring some new curious fact to light. But with the advance of knowledge we find that every science makes demands on every other science, and that the best type of specialist is one whose general knowledge is so vast and so precise that he can interpret the phenomena observed in his special province. The studies of Dubois-Raymond, for example, on Animal Electricity involved a knowledge of physiology and of chemistry, as well as of the phenomena more exclusively related to electricity. The study of physiology involves that of chemistry, anatomy, and mechanics. The study of chemistry, especially in regard to its later brilliant

developments, involves a clear comprehension of the principles of physics. The researches of Helmholtz with regard to theories of vision, which gave a concrete result in the invention of the ophthalmoscope, involved a knowledge of physiology and mechanics. His researches on musical notes involved the application of a considerable range of the Higher Mathematics. The whole scope of his observations led him to throw new light on the field of psychology.

Graham's researches in osmosis derived their importance mainly through their applications to various physiological processes of respiration, of digestion, and excretion. Graham studied the laws of the interchange between bodies, in a gaseous condition, for example, contained in chambers separated by a porous diaphragm. Here again we have an instance where physiological problems lead to those of physics and chemistry.

The study of meteorology may be called a specialisation; but the proper comprehension of the subject involves an extensive acquaintance with the methods and results of various sciences. The questions that primarily present themselves may be said to be those of physics, such as the problems of the heating and expansion of the air in certain regions, the inflow of the colder air from other regions, the production of winds in consequence. But this problem soon became of extreme complexity owing to the influence of the earth's rotation in causing deviation of the direction of the winds; and owing to the various conditions of cooling on account of the distribution of continents, with ice-clad tracts, mountain ranges, wide expanses exposed to the sun; and the vast ocean areas, with their systems of warm and cool currents also. Here already we have added to the problems of physics considerations derived from physical geography and

astronomy. The problems of astronomy involved are rendered complex by the influences produced by the movement of the earth in its orbit, its approaching and receding from the sun, its varying speeds in its orbit, its successive presentations of different areas to the greatest heat of the sun owing to the obliquity of the ecliptic with respect to the equator.

These problems are again complicated by considerations of the effects of terrestrial and solar magnetism. This introduces us to a branch of astronomy usually treated as separate from that of gravitational astronomy, and demanding the co-operation of the work of specialists within its own field. In this way also we become introduced to a vast domain of terrestrial and solar chemistry, one of the aids of which is derived from spectrum analysis, which itself forms a special subject of absorbing interest.

The condition of the atmosphere is also influenced by the conditions of the central heat of the earth, and by disturbannes of the earth's crust. Here we become introduced also to the very complex problems of geology.

As a tentative aid to our observations we seek to compare past results, to endeavour to form the means of demonstrating cycles of climatic disturbances. Then within a narrow scope the meteorologist keeps himself informed of the climatic conditions in various parts of the globe. Hence he is dependent also on a science of statistics.

It will therefore appear that for the proper understanding of special subjects a vast amount of knowledge of other subjects is often not merely useful but essential.

Let us consider in this respect one other subject, that of bacteriology. Bacteria being microscopical objects we must necessarily in our investigations be acquainted with the use of the microscope. This

implies not only a knowledge of the principles of the microscope, but also a familiarity with various interesting points of technique, such as that of securing good illuminations, of illuminating from the side, or from above, and so studying the bacteria under various aspects; or by the use of the "ultra-microscope," employing an exceedingly fine beam so as to bring to view objects otherwise invisible. There is also a device by which the bacteria may be exhibited in movement. A drop of water containing living bacteria is deposited on a thin piece of glass called a cover slip. But as it would be impracticable to dip the end of the microscope containing the object-glass into this drop, the cover slip is inverted so that the drop now hangs down. But since it would again be impracticable for the cover slip now to touch the glass side on which it rests, it is separated from it by being allowed to rest on the ridge of some substance such as vaseline of a height slightly greater than that of the depth of the drop which is hanging downward from the cover slip. The technique is hence called that of the "hanging drop."

The question of microscopy involves that of glass-making, and this is so important that a distinguished German professor, Abbé, turned from his labours in physics to devote his attention to the manufacture of glass, and in the end laid the foundations of an important industry in Germany.

The question of increasing the power of the microscope has also demanded the attention of scientific men, and Gordon has devised a system which may be briefly described as superposing a microscope upon a microscope so as to multiply the effects; and this under certain circumstances is of the highest value. The question of microscopy is so vital to bacteriology that one of the most distinguished bacterio-

logists, Sir Almroth Wright, has written a substantial volume on the subject of microscopy alone.

The problem of the microscope in bacteriological work is complicated by that of staining materials. The bacteria cannot be studied in animal tissues without the use of stains by which they can be rendered distinct. The use of stains has also brought to light this fact, that some forms that might not be otherwise differentiated show different effects towards certain stains, some staining, for example, with an agent called Gram's stain, and others not staining at all with Gram's stain. Some of the most important discoveries, such as those to which the name of Schaudinn is attached, in bacteriological work have been due to the selection of appropriate stains.

The whole question of the effects of stains on animal tissues and on bacteria forms itself an engrossing subject of study, and much work has been done towards its elucidation, particularly in Germany.

It is evident that the stains operate by reason of chemical reaction with the organic tissues, and by this means we are enabled to make such rough divisions as those of the parts having most affinity for acids or for bases. The whole question therefore involves a great range of chemistry; and also, for its interpretation, of physiology.

The observations of Koch respecting the possibilities of the culture of bacteria in certain substances, or culture media, gave rise to a branch of the science at which a host of scientific men have worked. The questions to be settled experimentally were those, for instance, of the best kind of media for different bacteria, the best conditions of temperature, and the limits both of heat and cold at which they were killed. Different behaviour under similar conditions suggested principles of division

for further classification. The whole scope of the problem thus becomes that of a science of natural history of the bacteria, the conditions of their climate and habitat generally being varied experimentally.

Thus it becomes clear that if bacteriology be taken as a special study, mastery in this specialisation can only be acquired through the knowledge of a considerable number of associated sciences.

But if we now turn to the applications of bacteriology we are led to believe that in medicine the problem of small-pox will almost certainly find its solution in some new discovery of bacteriology, and that the study of cancer may possibly be advanced by similar means.

Subjects the most remote become in wider knowledge linked together. Studies of Natural History involve those of physiology, and physiology involves electricity.

The science of electricity has been developed by means of an elaborate system of mathematics. The development of mathematics has often depended on the consideration of questions of the finest analysis trenching on the domain of psychology. Thus the keenest insight of Abel or Riemann, the subtlest analysis of Berkeley or Spencer, the recondite speculations of Pythagoras or Kepler, have in their developments resulted in fruits of practical value.

The question of specialisation is therefore never a question of the limitation of the subject, it is only to be considered in reference to the limitations of the student, his faculties, his quality of mind, his knowledge, his opportunities, his energy, his time.[1]

[1] Even in special subjects, such as mathematics, we find that the results of one branch are often invoked in studies that apparently have little connection with it. Landen's transformation, for example, shows the application of geometry to the problem of elliptic functions. Riemann was able to solve questions in the domain of the theory of numbers by reasonings which passed through the route of elliptic functions, and the theory of functions in general.

The story of Sir Humphry Davy attending Coleridge's lectures on poetry now finds a clearer explanation. These lectures stimulated the general activity of his brain, causing associations to be formed between tracts not likely to be inter-linked by severe studies in one domain. Amongst the multitude of suggestions passing through his mind, which he dealt with on the general principles of his science, he found some that suggested investigation. His method of investigation was that of a series of bold guesses which he afterwards tried to verify (cf. p. 395). But this method is, as we have already gathered (cf. pp. 332 *et seq.*, pp. 384 *et seq.*, and p. 398), not different, except in regard to the manner and temperament of the particular investigator, to that of all scientific research.

Faraday said that Davy by his example illustrated to him day by day what he should avoid in scientific research. But this criticism involved rather questions of the technique of the laboratory, cleanliness, neatness, accuracy, method, and system. Davy's mind was far more orderly than the arrangement of his crucibles, and his guesses were the result of profound thinking on the basis of generalisation and classification. Certainly his lack of care in regard to mechanical details was likely to produce error and to cause him to overlook facts of importance. But the difference of his method from that of Faraday might be compared to that of a brilliant and dashing military leader who takes chances, from that of a slower, methodical, and careful general who completes a carefully laid strategic plan point by point.

In regard to diversity of knowledge there is danger not so much from the incompatibility of studies, for the most remote experiences may finally become linked in a luminous chain of thought (cf. p. 190); but there is disability simply from the actual conditions of time and

space under which we labour. Our lives are so very short in comparison with all we are capable of doing, that all must renounce even the culture which would under more favourable conditions be necessary for the full appreciation of their own special sciences. There is no incompatibility, except in point of space and time, between the labours of an astronomer and a bacteriologist; but few indeed would find it possible to acquire a mastery in both these sciences. Again, it is given to few to excel as leader of armies and as admiral, though certainly the qualities of mind required are not dissimilar.

In olden times there was a frequent association between poetry and mathematics. Pythagoras studied problems of harmony, and to him is due the phrase "the music of the spheres," which again is founded on a mathematical expression, viz. that of the order of the distances of the planets. Plato, whose thoughts are steeped in a poetic atmosphere, inscribed over the door of his school that none should enter who knew not geometry. In later days Leonardo da Vinci combined great mathematical and mechanical skill with a temperament ever inclined to research of poetical ideals. Pascal's mind was suffused with poetry which gives charm to his *pensées* beyond their philosophical value. Even Kepler's speculations arose out of a kind of mystic Pythagorean poetry involving mathematical forms. In recent times such combinations have been rarer, principally, no doubt, owing to the exigencies of the study. Caryle, however, had shown aptitude for mathematics, and Sylvester cultivated the graces of the Muses. The mind of Evariste Galois was of an ardent poetic type.

Yet withal, regarding the vastness of the survey now required in each of the great sciences, it is necessary severely to limit the range of mental activity. Bain has

pointed out that it may be an advantage in regard to the prosecution of any given study to have distinct limitations of taste and aptitude for all that might prove of the nature of distraction.

Darwin, for instance, found, as his interest in the scientific aspect of things increased, that his zest in sport diminished. Later he acknowledged that all his æsthetic tastes had departed, except a liking for good prints. The only effect of music was to stimulate his thought. Newton saw in statues only "stone dolls," while he considered poetry a "sort of ingenious nonsense." And in the whole range of Shakespeare's work it would be difficult to find significant allusions to the profound scientific problems discussed in his day.

The question of complexity of a problem may be separately considered.

Let us take a few examples. The steam-engine has a very complicated appearance to any one unacquainted with the principles by which it works. But if the principles be made clear step by step in such a manner that the student well understands what has been explained before proceeding to the next point, then the impression of complexity becomes less.

In this way it is best to explain the essentials first, and perhaps diagrammatically—though the use of diagrams should not be abused in instruction lest the student become again embarrassed in observing the diversity of details with which he has not been made familiar.[1] The movement of the piston in the cylinder owing to the expansion of steam behind the piston is easily understood. The necessity of providing some means for the escape of the steam when the process is reversed is also easily suggested. The main problems

[1] Edison avoided as far as possible the use of diagrammatic indications, preferring to make his studies on the actual system.

of difficulty are how to devise an arrangement of valves by which the entrance of the steam behind the piston at one end of the cylinder may be provided while, at the same time, communication between the other end of the cylinder and the external air (in the simplest type) may be allowed; and, further, how the arrangement of valves and communication may be utilised in the reverse movement—viz. when the piston has traversed the length of the cylinder and must now be made to return.

Then there is the problem of converting an up-and-down movement, as of the piston, into a circular movement, as of a wheel. This transformation is effected by means of a crank, the working of which is easily understood on trial, although to those unfamiliar with machinery it is possible that many suggestions and tentative practical efforts would be necessary before the device of the crank became invented.

Once in possession of the main principle, and with a clear view of the most important parts of the machine, we find that the details present no great difficulty (cf. pp. 388-391).

Though the best way of arriving at an understanding of the steam-engine is that of first observing the essentials as described, yet it is possible that an individual always occupied about a steam-engine and accustomed to the details, one by one, might arrive at length at such a comprehension of the working of the whole machine that the first impression of complexity would have been lost (cf. pp. 46, 344, and 401).

We see, then, that the impression of complexity is given by the consideration of a great number of objects associated in certain relations, particularly of dependence on other objects in such a way that the understanding of the nature of these objects is a condition necessary to

a clear view of the relation of dependence. Hence in the understanding of a complex piece of machinery, as in the understanding of a number of diverse but associated objects in nature, we search by our analysis for some basis, which in one case is that of a generalisation affording a classification, and in the case of a machine is a principle of working, so that the associations that proceed from it are of that close kind which we express as of cause and effect. A reference to the discussion of the advantage of classification (cf. pp. 386-389, also pp. 140, 236, 340, 383, and 400) will make it clearer also why the effort of Memory and of comprehension is easier when the machine is studied from its main principles onwards.

We see that familiarity or ease of reference, which results from repeated observations, diminishes the impression of complexity; for it leaves the mind free with all its energy to understand the step following those already considered.

The graphic representation, and particularly the study of the machine from an actual example, is of value in this respect because the Memory is aided by the more vivid direct impression, and also by the multitude of associations that form about a concrete object observed in many relations.

The study of the steam-engine also shows us that the part least difficult to understand is that of the principle of working. The ancients were familiar with the explosive and expansive effects of steam, but they did not know how to adapt this property to practical use because the arts on which that use depended had not been sufficiently developed.

This consideration reinforces what is said elsewhere in regard to the importance of a good knowledge of technique in matters where mechanical contrivances are

necessary for the exploration of any domain of speculation (cf. pp. 405, 408). Watt, who invented the steam-engine in a practical form not greatly different from the best steam-engines of the present day, was an expert in mechanical contrivances. Thus the difficulties of complexity would not be present to his mind in the same degree as in the case of one who had only seized the main principle. Hence we learn with interest, but not with astonishment, that Watt prepared the main part of the work of invention during a quiet walk along the street.

Similar impressions of complexity occur to the mind of a lawyer who has to master a very long and involved case. It was the late Justice Hawkins, I believe, who declared that when he had looked at his brief for the Tichborne case he felt like a swimmer who had to swim across the Channel. In that case, to the impression of complexity was added the premonition of the physical efforts necessary to be put forth.

The lawyer seeks for a guiding thread, or main line, or for the essentials of the case. These expressions refer to processes of analysis similar to those of obtaining the principles of classification, or the principles of working of a machine. Considerations of the kind would eventually lead us, in regard to works of permanent interest, to a discipline of study that might be called a logic of book-reading. In examining a great book, such as Spencer's "First Principles of Psychology" or Bain's "Education as a Science," it is not sufficient merely to proceed from position to position with the impression that the argument is justified. It is necessary to a good understanding, so to analyse the book that, cutting away what has served its purpose of illustration, we see the structure of the book in the form of a Classification, with a clear appreciation of the prin-

ciples of division, and the relations between all the parts.

But that is not all that is advisable. We should search to find the germinating idea, the principle, which gave rise to the book, and we should trace up the development from that basis. And in this way we should become so familiar with the essentials of the exposition that the details no longer have any air of complexity; so that the mind, being left free with its natural energy, may suggest new modes of exposition, or illustration, or may anticipate arguments, or make open the way to new developments.

We must revert again to a consideration of mathematics, for it is there that we find the most striking examples of complexity.

In this science we have already noted the long consecutive arguments from a base easily comprehended, and we have noted that each step of that argument must be understood before the mind can profitably proceed on its course. We note also that as the development of the science proceeds, there are frequent appeals to results already obtained. In such a work as M. Poincaré's "Nouvelles Méthodes de la Mécanique Céleste," all the resources of graphic geometry, with its developments, are called into reference, as well as all the resources of the analytical methods of the differential calculus, all the resources of that other development of algebra which makes the science of determinants, while in the determinants themselves we have the expressions of special branches of study such as those of integral invariants.

Here there is a high degree of complexity, and the impression of complexity is increased by the abstract nature of the conceptions and the recondite associations of the symbols. But in this complexity nothing new is

introduced beyond what we have already considered. As we proceed with demonstration following upon demonstration, we make demands on our Memory. Constant repetition is therefore necessary in order to secure that familiar ease of reference that leaves the mind with sufficient energy to grasp each succeeding demonstration, and to behold it in all its relations. The familiarity should be of such a kind that, when one meets with an expression which is not of the form of a known result, but is capable of being reduced to it by means of known results, the mind ought to be lively in apprehension and suggestion.

Assuming that at any step the mind is familiar with acquired results, and that the Memory is good and active, then there is no complexity in proceeding to the next result, for the terms of the demonstration should make it as plain as possible. Even in working over a new problem, the method of analysis poses at each step a definite problem, which makes the matter as little complex as the mind finds convenient. Hence it is not uncommon for those accustomed to such abstruse speculations to work over and solve problems in the Higher Mathematics while walking about a street, or while engaged in other not absorbing occupations (cf. pp. 402, 413). Pascal solved the problem of the cycloid while tortured one night by the pains of neuralgia.

The impression of complexity is therefore entirely due to the sense of the effort required to traverse the whole train of demonstration, and hence in part to the work involved in retaining in Memory a considerable amount of acquired results which by reason of their abstract character have no strong associations. These conditions involve frequent repetitions, or else the Memory becomes dim, and the effort of reproduction is notably increased (cf. pp. 290 *et seq.*). If in the end the

mind becomes very familiar with the whole field involved, the sense of effort becomes lost, and with it the impression of complexity.[1]

To the complexity involved in the necessity of memorising a great number of formulæ and their relations, may be added, in dealing with geometry, the complexity of constructing intricate figures in the mind. In dealing with new problems it may be necessary to alter the construction tentatively from time to time. Hence it often happens that such problems make a greater demand on the attention than problems which depend on the transformations of formulæ.[2] We have seen in the case of the steam-engine that the complexity

[1] Thus it requires a considerable mental effort to arrive at the idea of the multiplication of $\cos \frac{(2p+1)\pi}{n} + i \sin \frac{(2p+1)\pi}{n}$ by itself.

Indeed, the mind is unable intuitively to comprehend the process. But suppose that we have been familiar with the fact that the multiplication by itself of $\cos A + i \sin A$ gives as a result $\cos 2A + i \sin 2A$; and that we have already ascertained that in the process involved there is no reason why the angle $(2p+1)\pi$ should not be symbolised by A; then the result seems to offer no great complexity, for in the expression required we have only to double the original angle. Thus the proposition is that if $\cos \frac{(2p+1)\pi}{n} + i \sin \frac{(2p+1)\pi}{n}$ be multiplied by itself the result is $\cos \frac{(2p+1)2\pi}{n} + i \sin \frac{(2p+1)2\pi}{n}$.

The relation expressed is a truth; the complexity has reference to our own minds, and the means that we adopt to arrive at this truth.

We might accordingly point out that if we were forced to depend on feelings of touch and the sense of muscular effort, then we should find very complex a landscape, with all its relations, which ordinarily we take in at a glance.

Or again, if we say the principal ordinate of any point on a parabola is a mean proportional to its abscissa and the latus rectum, we express a truth that is so bound up in the nature of things that we cannot form a parabola, but that, whether we actually draw any particular ordinate or not, the relation exists. There is no more essential complexity here than in the case of the falling of a stone. The complexity resides simply in our manner of arriving at the recognition of a truth that exists invariably.

[2] Prof. Klein, the brilliant German mathematician, pointed out a classification of mathematicians, according to their bent towards graphic representations. At a recent meeting of the British Association a paper was read which expressed the opinion that some geometers were naturally inclined to the direct transformation of formulæ, others to conceptions by means of graphic representations. Sir J. J. Thomson expressed concurrence.

was rendered less when the opportunity was afforded of studying with the actual machine rather than by means of a representation in ideas.

This suggests in regard to the study of mathematics that a considerable advantage would be obtained by the actual tangible representation of all geometrical figures, and indeed all relations which can be graphically expressed.[1] Even complex geometrical constructions ought to be so exhibited; and this is especially useful when it is necessary to consider geometrical figures, under changing aspects. To each figure its formulæ should be conspicuously attached. Thus in the work of mental constructions we would be aided by virtue of Memory being made facile.

There is nothing unscientific in this method, for though in mathematics we deal with abstractions, yet these abstractions are founded on concrete objects (cf. pp. 44 *et seq.*). It must also appear reasonable that we may form as clear an idea of an isosceles triangle, or an ellipse, from a well-constructed representation in metal as from chalk lines on a blackboard.

Another illustration of complexity may be obtained from quite another field. Since, as we have seen, complexity refers to the difficulty of acquiring, without repeated experience, a knowledge of a great number of things and their relations; and in the second place to the difficulty of recalling our acquired knowledge with relations appropriate for comparison with new experiences; then the impressions, say of a countryman in a large city, would be those of complexity. And so we actually find it. He says that he becomes bewildered, or lost, just as one might become bewildered at a discussion on Bimetallism, or lost in the endeavour

[1] Cf. "Une Question de Représentation Géométrique" (Paris), by the author.

to trace consecutive reasoning in Kant's "Kritik der Reinen Vernunft."

A problem of complexity in regard to movements in a large city might be of this character: Start from Clapham. Take the first train after noon that will bring you as near as possible to Charing Cross. There ask a policeman the way to the National Gallery. Take a guide-book and find your way to Turner's pictures representing Carthage. Study the colours by comparison with a plate of a spectrum. Note the dominant colours. Then proceed to the British Museum. Look up in the catalogue a work bearing on Turner. Search in the index for reference to the picture. Compare your own note with the notions expressed by the book.

The problem, by reason of its complexity, would be beyond the capacity of many. But to any one already acquainted with London, and already versed sufficiently in the matters referred to, the suggestion of complexity would hardly arise.

Every cabman who finds his way about London and does his regular business deals with problems which from the base up are more complex than some of those of the Higher Mathematics; but incessant exercise from the earliest days of observation onward, combined with the advantage of dealing with visible, tangible things containing varied Associations, make Memory more facile, and familiarity of experience removes the impression of complexity.

§ II. Application to Discovery

If we now consider the whole question of discovery, we shall find no rules that lead inevitably to definite results, but we shall observe certain guiding principles that will be of service.

Of these the most important is the desire of knowing the truth in preference to the defence of any kind of preconceived position. We have already noted the progress of the mind in regard to a set problem. But as all discovery proceeds tentatively, the method is that of posing a problem which we seek to verify. It may be that the problem is of the nature of a somewhat recondite hypothesis, such as that of the undulatory theory of light, in the investigation of which many problems lie in the way.

The question of research then becomes resolved into that of setting forth hypotheses with the best judgment, or posing problems likely to lead to new discoveries.

We have had occasion also to consider what is meant in such cases by good judgment. It is the observation of concordances with what we have learnt to be the fundamental and well-established principles of a science; or the observation of cases of apparent, or possibly, if the principles be not true, real discrepancies with these principles (cf. p. 353).

We should presuppose therefore in the investigator a knowledge of the directing principles of the subject investigated. The greater the acquired knowledge both of facts and principles the better, other things being equal. But in some sciences the exhaustive study of all that has been investigated might make too great demands on the time and energy of the student. Thus erudition may be useless if it prove a bar to a certain liveliness of mind, freedom of association, and activity in setting forth and testing new problems.[1]

With the necessary acquired knowledge there should be cultivated a habit of persistent analysis (cf. p. 390),

[1] Priestley affords an instance of a man accomplishing great work in science, though but little versed in its learning. It is said that when making his discoveries in chemistry he could not have carried out a quantitative analysis.

and that form of arranging and regarding facts, and seeking correspondencies in essentials, which we may speak of as generalisation and classification (cf. pp. 388, 390, and 391). The progress of a scientific mind is marked by proceeding from the observation of particular cases to the search of the general principle involved; and from the general principle to the determination of other particular cases differing from those already observed; so that agreements between them may be thus exhibited and discrepancies at the same time explained (cf. pp. 380 and 412).

A habit of classification will in general be found associated with accuracy of observation and record. A certain formal method is no doubt helpful in such matters, for many discoveries are due to the mere comparison of facts exhibited in statistics.

A natural energy expressed in activity of mind is in itself of great importance, for this implies, all things being equal, a greater rate of progress in the examination of problems, and it also implies a greater surety of Memory in as far as dependent on the quality of the mind itself (cf. pp. 234 *et seq*).

The faculty of Imagination we have seen to be resolved into that of seeking resemblances and concordant associations whether of observation or construction; but the term would be more likely to be used where the fields thus associated might appear at first sight to have little connection with each other (cf. pp. 394, 395, and 408).

This implies that the mind must not be too narrowly absorbed in a certain field after that field has yielded all that it can give. The danger, however, is that the attention may become diffuse and that Memory and associations may become dispersed over too great an area (cf. p. 409).

Hence it may be a disadvantage to possess intellectual qualities or artistic tastes, even of a high order, but likely to lead to dissipations of energy; and conversely limitations in this respect may be a condition of greatness.

A deep interest in the matter of study is essential, for this implies the continual recurrence of the mind to the same field of exercise and associations with all that is otherwise observed in the course of other experiences. A mastery of the technique of the subject is very important. A man of science accustomed to the use of the instruments of research is able to test the suggestions which arise in his mind, and to learn something even from those that may not have seemed productive. On the other hand, a person inefficient in the technique of a subject leaves these suggestions vague in his mind, and for that reason does not proceed (cf. pp. 405, 408, and 412).

In mathematics skill and technique would be represented by familiar acquaintance with formulæ. Efficiency in technique can only be acquired by practice. Hence the value to a scientific man of laboratory work. The constant daily service, the familiarity with methods, the faculty of testing new suggestions, are all matters of invaluable aids. The danger is that he may become limited to a certain routine; that he may be inclined to defend some preconceived thesis instead of searching always for the truth; or that he may be deficient in knowledge which, though really bearing on his subject, perhaps even being indispensable for the explanation of some of the phenomena observed, yet has lain outside a prescribed study of his speciality.

Or again, a good laboratory professor may be deficient in the speculative and imaginative intellect necessary to pierce through accidentals and see in remote things essential resemblances.

Certain it is that some of the greatest advances of science have been due to those whose study has been outside the schools of learning in these matters, and that frequently those who have had least technical knowledge have thrown the most illuminating light on a subject. One reason is that their attention is not absorbed by a mass of details, and that their minds pursue a course of analysis more persistently.

Another reason not without its influence is this: That in science as in all other subjects of human activity emulation is of great importance (cf. p. 390). Now one who is in constant touch with fellow-workers is more apt to spend his energy on the points that arise in discussions, and to obtain results which he knows how to set well in the light. A solitary thinker must strike down deep into general laws before he can obtain anything worth presenting to the world. The examples of Darwin, of Dalton, of Herbert Spencer, may be cited.

A methodical manner of work; great accuracy not only of observation but also of record; a system of explanation well conceived and steadily worked through—these all seem factors of success in the way of discovery.

Yet all that has been here written must be regarded in the light of guiding indications, not as rules. Some men, even of great general aptitudes, seem to have an irresistible bent towards certain fields of speculation. Thus we have the elder Herschel, who in the intervals of playing in a band advanced the science of astronomy amazingly; Spinoza, whose whole passion in life was that of metaphysical speculation; Evariste Galois, who at the age of twenty-one had thrown illumination on the heights of mathematics; Darwin, whose career is summed up in the elaboration of his theories; Descartes, who hid himself in Holland the better to think in his solitude; Galileo, who faced the terrors of the Inquisi-

tion in his overwhelming desire to behold the truths of Nature.

That which seems most important to all work of discovery is a great deal of preliminary work in the field of research. A mind persistently and actively occupying itself in a certain domain has, however, need occasionally of gaining ideas outside those found in a set routine.

§ III. "The Whole Man Thinks"

During the whole exposition of Reason the Fundamental Processes have been continually referred to. Even when some more complex term such as abstraction, space-association, comparison, has been employed, it has been made clear that it could be analysed to these Fundamental Processes (cf. p. 183).

The Hedonic accompaniment deserves separate notice, for in what is called pure Reason its influence may seem less evident. The Hedonic accompaniment is, however, invariably found with the Immediate Presentations arising from any of the sources of our knowledge of the external world; and as ideas are formed in Memory from these, we have the whole of the elements of our knowledge affected hedonically.

We have seen that the development of Reason proceeds step by step with the development of all our faculties, for it is dependent on them. Consequently, if we retrace the lines of development of our organised faculties, we shall find at length the beginnings of Reason in the instinctive acts that appertain to the preservation of life (cf. pp. 93, 114, and 234). Of these the standards, the directives corresponding to "yes" or "no" in the determination of movement, are feelings of pleasure or pain.

In our higher development we find that the problem is enormously complicated by contrasts between present pleasurable and painful states and the sense derived from a consciousness of the total personality as not being bounded by limited time and circumstances. In this regard the individual follows out strategic or tactical lines in which the present state is considered in reference to the general scheme.

Further, the importance of secondary motives, and the pleasurable exercise which their pursuit involves, obscure at times the primary motive from which alone they were produced. Holding a clear view, however, of all these complications, it may be said that in rudimentary stages of life, and step by step through every development, the arbiter of our Reason, and the standard of our conduct, in so far as that depends on Reason, is that of the Hedonic sense.

This position, it seems to me, so far from being at variance with philosophic thought, is found at the very base and origin of that thought itself. I must, however, call attention to the reserve of "conduct, as far as that depends on Reason," for this present exposition is one of Psychology, and not of ethics; and it is bounded by the forms of Reason.[1]

But suppose that we were the instruments of a Purpose which bears us on in a stream of which our limited Reason can only confusedly and imperfectly give us conception, and that this limited Reason were itself but a mode of influencing the instrument; then another conception of ethics, or of right and wrong, of the paradox of self-sacrificing duty arising amid hedonistic standards, might be dimly adumbrated.

It is, moreover, advisable to warn against too narrow

[1] Compare what has been previously said in regard to the systems of Epicurus and of Herbert Spencer (cf. p. 319).

an interpretation being placed on philosophic terms. The view of the Hedonic influence in Reason might well be consistent under special conditions with Stoic practice.

The importance of the Hedonic accompaniment must not be, however, in any manner misjudged. With this position established it would be possible to pierce the fallacy of Kant's "Kritik der Reinen Vernunft," wherein he sets forth the Categorical Imperative in a non-Hedonic sense as the origin of right conduct. But here the limitation must again be referred to, that these arguments apply only within the scope of Reason.

Kant's whole position will be found to be a vast *petitio principii*, having its origin not in a determined and ultimate analysis, but in the temperamental needs of one inclined to the Stoic philosophy, but greatly unsettled by the trend of the revolutionary thought rising into activity in his day.

We observe also how the actual experience is dependent on the direction in which a man's natural bent, his talents, and his acquirements will lead him. And, moreover, we observe that not only every mental phenomenon implies a physical correlative, but also that the moral and emotional qualities are dependent on physical conditions.

Thus, reviewing the whole of these circumstances, we find ourselves brought to a conclusion expressed elsewhere in aphorismal form: The whole man thinks.

§ IV. The Criteria of High Mental Development

The examination of complexity in regard to the objects of study suggests the consideration of complexity, as one of the marks of evolution, in the mind of the

man. Let us consider some means of estimating the value of a mind.[1]

Man's life is a perpetual struggle for progress within the environment of the whole Universe. Certain of the forces of Nature appear to him at one stage as obstacles. Subsequently he makes use of these to subserve his ends. In the early part of his history he has been occupied with the problems of material subsistence. Later, he has more leisure to think. At first his thoughts are greatly concerned with the further and remoter provision of his material wants, and with conflicts, either personal or collective, with his fellows.

Not merely generations, but centuries upon centuries, of human history have been occupied with matters which have implied no general advance. A few great thinkers have arisen from time to time, who have elevated their minds above temporary interests and have sought to penetrate the secrets of Nature, but their discoveries, from those of Archimedes to Roger Bacon, to the marvels of our own day, have often been employed for the old work of destruction.

In this way, slowly and painfully, mankind has struggled on. The problem of subsistence, the problem of every advance, even in material welfare, has depended on searching the mysteries of Nature.

Nature is always tacitly putting questions to us, and rewarding us, or our race at least, for correct solutions.

We find, then, that the thinker is the artisan of the world's progress. Certainly, in considering human greatness, we appreciate, apart from purely intellectual domains, examples of great character, of physical perfections, of the development of all the arts that embellish life, of poetic

[1] The literature on this particular subject is scanty. Cf. Ostwald, "Grösse Männer" (1910); and Ch. Henry, "Mesure des capacités intellectuelles et énergétiques" (1906).

aspirations that hold our ideal on high. But these are not essentially incompatible with high intellect, though it has been found in the course of our human history, and the accidents of personal surroundings, that the thinker has often been compelled to surrender nearly all except his desire to know (cf. pp. 410 and 421). But it is true that in communities where thought has reached a high level, even at the sacrifice of the individual thinker, all the other incidents of greatness will be found well developed.

With all the reserves therefore implied in what has been said, we will consider Reason as a standard of development. From the previous exposition of the condition of Reason, it appears that the intellectual quality depends on certain characteristics which have a physical base—unimpaired senses, energy, lively apprehension, and retentiveness as in Memory. But the clansman may have all these at a higher level than the man of science whose works shed a lustre on humanity. We have seen also that in the circumstances in which we are placed a richness of natural endowments may result in actual disadvantage, for it results in too many distractions (cf. pp. 97, 237, 410, and 421).

We have therefore to consider the man in relation to his field of work. Besides, we are inclined to judge the value of work by comparison with that of others. For example, a man of lively intelligence who has traversed the world, and made observations in many countries, may have a greater natural endowment, and he may have associated and co-ordinated far more ideas than the man who has studied one corner of the earth. But the traveller may not, in any one subject, or with regard to any one country, have made original observations not covered by some one else; whereas the man who settles in one place may have brought to light some

new truths about the geology of the place, about folk-lore, or about the habits of the birds. We have already seen that too narrow a specialism may be inadequate even for the purpose of the special study; but it requires less argument to indicate the dangers of dissipation of energy.

The traveller may be of great use by virtue of his general information, but for our purpose we will take as the test of the value of work the discovery of something new. The product in this way may be always made the criterion as to whether a man has gone too far afield or has linked himself too closely in a special study. We behold the external world presented to us in myriad guise, the accidental circumstances, the ornaments of which cover up the secrets Nature offers us.

We have seen, then, that in addition to bright natural intelligence there must be found a habit of thinking by means of deep generalisation and classification (cf. pp. 388, 389, 391, and 420).

And as in most of the subjects of special interest, a succession of men of great intellect have worked in the field and obtained valid results, expressed in general laws, it would, generally speaking, be wasteful of time and energy to begin all anew (cf. pp. 387 and 398). Study, serious and prolonged, is necessary in the sciences, even for a man of great original capacity. His originality will find abundant scope when he reaches the point where the science of his predecessors fails.

The discovery of any truth in science is useful, but, both by reason of the actual disposition of things in Nature and of the mode of working of our minds (cf. pp. 386 *et seq.* and p. 410), the expression of a general law is of greater value, for with a much less effort than required for its discovery, thousands of new truths are brought to light.

If we take a practical illustration, as for instance that of the steam-engine, we know that after Watt had invented the standard type, steam-engines of all sorts, with devices adapted to special circumstances, made their appearance.

Mankind had waited thousands of years for the inventive genius of Watt, but any of a multitude of minds were capable of devising adaptations of the principle.

The researches of Carnot into the nature of heat, and of work, and his studies of a theoretically perfect engine, more abstruse than that of Watt, have been of great practical service in directing the engineer to secure the greatest efficiency possible in his engine. And as the demands of civilisation become greater, and competition keener, these investigations will bear fruit in regard to all types of machines.

The problem posed to Watt was how to make use of the energy of steam. The salient data of his invention were: Movement of piston from expansion; transformation of rectilinear to circular movement. These results became adaptable to anything propelled by wheels; hence to locomotive engines and to steamships.

The discovery of petroleum in large quantities suggested adaptations in regard to the other part of the data, that of expansion. The engines used in motorcars do not now depend on steam, but on petroleum. The expansion is produced by the gas which is the production of fresh combinations brought about by the passage of an electric spark.

When, however, we classify steam and petroleum, we find that, in seeking the principle of division by which we arrive at such a generalisation as Carnot had in mind, the question then becomes posed: How are we in the

most efficient way to make use of the stored-up energy of any material, be it coal or oil or explosive powder, so as to obtain useful movements? The philosophic horizon becomes enlarged by this contemplation, especially when, in view of the principle of conservation of energy, we seek the source of any form of energy. Coal, for example, is transformed vegetable material, and the energy of the vegetable world depends on the heat of the sun. Accordingly, if we use coal for a steam-engine, and use a steam-engine to turn a dynamo, and use the dynamo to heat a wire, we have by a series of changes completed the cycle from heat to heat.

Such a scheme as Moleschott's cycle of life shows a similar transformation in regard to living things.

With such an enlarged view of the whole field we find it not difficult to form the associations between waterfalls and distant machinery. For with a knowledge of the principles of transformation of energy it is only a matter of choice of ways and means. We find it possible to convert the energy represented by the waterfall into that in the form of an electric current, and as we know that a current can be conducted through long wires, and that the energy of the current can by the the dynamo be exhibited in the form of movements of machinery, the problem is resolved into one of mechanical device and expediency.

But the development of the science of electricity has depended on the speculations, at first apparently only "theoretical," of great thinkers. Two of the greatest of them, Ampère and Clerk Maxwell, were above all things philosophers. They were both mathematicians of a high order, and they sought by virtue of their mathematical skill to interpret phenomena of electricity and to give them a general aspect in the whole field of physics.

Hence once more we come to the conclusion that

if in the persistent search for deeper and deeper experiences of laws we light upon a general principle, the applications, and finally the tangible practical results in the most material sense, are in multiple ratio to the depth of the generalisation (cf. pp. 386 and 390).

It is not meant to be implied that speculations are to be valued simply because they are recondite; but that they are to be valued for their comprehensiveness, and that the speculations of greatest importance in this aspect will be considered as recondite by minds of superficial working.[1]

People are frequently inclined to judge a man's work by the standard of mass instead of that of high development. Landor in his "Imaginary Conversations" makes Scaliger look askance at Montaigne's small literary production, while Montaigne slily pokes fun at the pedant for his estimation of values. There have been many of the type of Scaliger, but only one Montaigne.

Byron laughed at Southey, "whose annual strains like armies take the field," but Southey no doubt owed his reputation to the sheer bulk of his writings. Ten thousand writers may reach Southey's level of mediocrity, but the "Ode to the Skylark" and the "Ode to the Grecian Urn" are, each in its way, peerless.

It is perhaps in the world of philosophy, where one might least expect it, that bulk has seemed of importance.

[1] Mr. Andrew Carnegie, who made a great fortune in steel, having been asked who the world's twenty greatest men were, said that he thought the twenty men to whom the world was most indebted were Shakespeare, Milton, Jenner, Neilson, Lincoln, Gutenberg, Edison, Siemens, Columbus, Watt, Bessemer, Bell, Arkwright, Franklin, Murdoch, Hargreaves, Kaye, Stephenson, Symington, and Burns.

Dicta of this kind are less useful in throwing light on the march of civilisation than in defining the taste, associations, and scope of the man who utters them. Exemplifying this principle, though in manner delightfully contrasting with that of one of the "strong sons of men," may be cited the saying, to me, of a young American opera singer, that the Opera House in Paris was the centre of the world, and Jean de Reszke its greatest man.

A thinker of weight—many are inclined to think—is a thinker who has produced weighty tomes. Even had Herbert Spencer found a higher art, and to his fine thinking powers had added the faculty of expression in epigrammatic style, he would have been esteemed as lacking in force. Yet all Spencer's work will pass into the body of science in the form of a few guiding aphorisms.

A man is always capable of a great output at his own level, and if he be a politician, an orator, a popular writer, so that there is an ever-present stimulus to exertion, the output may be prodigious. But when the man and the questions of the hour on which he has exercised his mind have ceased to interest, who goes to his writings? Who now reads Brougham, a man of immense activity, and whose authority in the world of thought in his day was great enough to cloud the influence of the noble intellect of Thomas Young?

The great turning-point of modern medicine was formed by the experiments of Schwann which established the germ theory, and the not less brilliant work of Pasteur which was built directly from the base laid down by Schwann. But the name of Schwann, at least, is less known than that of the practitioners who in introducing antiseptic methods have applied one of the many results of his investigations.

Their labours were admirable, and science as well as public health have profited by their ability and perseverance, but after Schwann had established his "germ theory," and after Pasteur had demonstrated that diseases were caused by germs or microbes, it was within the competence of men of less intellectual calibre to introduce in special departments the application of these doctrines (cf. pp. 333 and 385).

The experiments of Hertz in electricity founded on

its analogy to light suggested experiments throughout a wide scope of radiant energy. The discovery of the X rays by Röntgen was one of the results of such experiments. But both the Hertzian waves and the X rays have had various applications of great practical value, each step in the establishment of which has been comparatively easy after the demonstration of the general principle. Even in the steps necessary for the wide utilisation of the Hertzian waves the discovery which led to the most important practical advantage was due to an exponent of scientific research, M. Branly. In the course of experiment he found that the Hertzian waves affected the conductivity of iron filings contained in a small glass tube, but that the conductivity was restored by giving the tube a sharp tap.

But in these circumstances is found all that is essential for a telegraphic language, such as the Morse language, which consists of combinations of dashes and dots, or long and short currents. If we have the means of interrupting a current and restoring it, then we can easily arrange for the production of whatever corresponds to dashes and dots.

Marconi has by his own practical genius developed and made commercially useful the Hertzian waves; but the thinker's laboratory supplied the keystone of the arch.

In all these instances it must be noted that the discoveries resulting from profound investigations are valuable not merely because, apart from what is known to all, they have the interest as of new or rare gems; but they are veritably more important by reason of the scope of the generalisation which defines them, and so are accessible only to minds accustomed to think on scientific matters always in searching the deeper causes of phenomena.

The value of a mind is rightly estimated not only by the development of the mind itself, but also by virtue of its product, and this depends upon the selection of its field of work. A great chess-player exercises powers of Memory and powers of combinations of methods, and comparisons of situations with known results, that are comparable to the toils of the mathematician. But the mathematician's field corresponds to objective realities.

Newton, in his later days, becoming alarmed at some of the interpretations of his discoveries, wished his calculations for the theory of Universal Gravitation to be considered in the light of mere mathematical exercises. Had they been so, the work of their solution would have been none the less, but we should have had the barrenness of all problems of mere games instead of the endless development which his theory opened up.

If a man would care to examine the vast works of the old alchemists, to collect their notes, compare their methods and results, and work over their experiments, he would have an immense task before him, and the result would be of little value. But Lavoisier performing work of this character on the valid results of true chemists, and applying his own genius of organisation, observation, and experiments, laid the foundations of modern chemistry.

Or again, if a man set himself to run after every improbable theory, or to refute all the errors that he finds propagated around his subject, he will have no time for any good positive results.

A certain degree of judgment (cf. pp. 353 and 419) is therefore necessary to guide a man in the direction in which he should launch forth with all his energy. The moral qualities implied in persistence and determination are no less valuable in regard to the opportunities of life presented. The saying of an American railway

magnate[1] may be here adapted: A pound of result is worth a ton of effort. And so even in science the criterion of excellence must be the definite achievement towards the understanding of the world and the mastery over the powers of Nature.

This shows the necessity of constantly forming associations that bear upon a definite subject of study. This, and the necessity of being familiar with the technique of the science studied, implies frequent practice.

It may happen in this way that a man of mediocre brain-power, and even of no great energy, but of constant plodding habits and a pertinacity of searching, may achieve good results, while an intellectual man who has too far dissipated his attention on many subjects may produce nothing new.

The quality of the mind must therefore always be considered with reference to the field in which it expends its energy. It must also be considered in reference to its power of appropriating the results of others, and its opportunities of becoming acquainted with what has been done already. The question of stimulus to exertion must also be taken into account.

Now, usually all these conditions are best found in some seat of science where an atmosphere of research prevails. The system of the German Universities, for example, is so good that a man who would be considered second-rate elsewhere might, if he took advantage of the training at one of the best German Universities, rise so far as to be considered as of the first rank. Accordingly we find that the leaders of thought and science in Berlin are not only University men, but also, to a certain degree, University products.

The dangers of this too close immersion have been

[1] Huntingdon.

noticed. Hence it has happened frequently, and particularly in England, that the great path-openers in science have either not been University men at all, or that they have broken away from the University traditions. Thus from Locke to Mill, and from Darwin to Spencer, we have had striking examples of this sort (cf. p. 422).

The consideration of high types of intellect would be incomplete without some reference to the motive and aims of the mind. One could not apply the term "great" to a mind which had employed its energies on useless or retrograde movements. A great intellect, even though closely occupied in fields of special research, should be able to relate its work to the whole body of science.

It cannot be given to many to survey the whole scope of science, its development and trend, as Humboldt has done in his "Cosmos," but every man of science should endeavour to trace out the broad lines of co-ordination with other sciences, so as clearly to perceive in due perspective the effect of his own work.

The man of science is apt to lose touch with the æsthetic arts, and to underestimate much that gives stimulus, and zest, and colour to the lives of others (cf. pp. 410 and 421); but he should find arising out of his own work a feeling of wonder, of sublimity, and perpetual interest which is itself a form of poetry. Otherwise he is a mere mechanician, even though his skill be exerted on fine materials. How great is the poetry that arises out of the deeper contemplation of Nature will be seen by one who reads the exalted imaginings of "Paradise Lost," and compares them in their weakness to the marvels revealed in the investigations of science.

What has here been said with reference to the standard of the mind will be found borne out if we take a review

of the progress of our race as exhibited in history. Let us compare our civilisation with that of the Greeks. In many aspects they seem to have been superior. The fragments of Phidias that have been preserved to us remain as the highest examples of art. But the original groups were but part of a frieze for the adornment of a temple whose beauty of structure was based upon purity of design. And the temple itself was set upon a pedestal formed by Nature, and chosen by the architect with an unerring sense of what was noble in art.

There is found in all these circumstances a combination of high æsthetic feelings, not warped or excited to exaggeration, but simple and natural, as befitting a work presented to the daily contemplation of the citizens. With these feelings went hand in hand a wonderful technical skill of the artists. The total product of the art is without parallel in the world's history. That art, however, exemplified only one aspect of a general view of civic life, of national life, and of the spiritual life, ennobled by high ideals, while admirably balanced in accordance with the faculties and purposes of man.

The poetry of the Greeks also reached a high level: to this day familiarity with Homer is looked upon as evidence of high culture. The physique of the people was excellent. Beauty was familiar and natural to their lives.

The cultivation of the virtues of strength and resistance amongst the Spartans has become proverbial in every land. In what way, then, was Greek civilisation inferior to our own? Only in one respect—in the development of positive science and all that depends thereon. All the battles, all the internal feuds, all the struggles of ambitious men for domination, have passed away; but the science of the Greeks has borne fruit. for

it gave the first impulse to the civilisation of Europe. The period of that efflorescence was, however, too short to permit of the vast developments which their thinkers had already dimly foreseen.

The dominions of the Romans and Carthaginians have passed away, and the sole valuable survivals have been the higher products of human thought.

The Dark Ages are dark because science was in abeyance, the minds of men were fettered, and the activity of the world was mainly occupied with wars and struggle for authority.

Modern history begins with the Renaissance of science. Not only the superior enlightenment possible at least in our day, but the vast material gains, the gradual advance of men in the control of the forces of Nature, even the explorations and the discoveries of all varieties of new resources, all the victories of our race in that wrestling with the world which is at the base of our existence, all these boons are the fruits of science.

The men to whom the progress of the world's civilisation is mainly due are those of the type of the great Greeks, such as Pythagoras, Hippocrates, Thales, Empedocles, Socrates, Plato, Aristotle, Apollonius, Archimedes; then, shining through the mists of the Middle Ages, noble intellects such as that of Roger Bacon; and at the dawn of modern civilisation subtle minds and lofty spirits such as Copernicus and Galileo; and later the constellation of modern thinkers, great analysts, profound students of the organic world, enlightened, bold philosophers who have shown the way to all that is distinctively great in our own time.

§ V. Provisional Summary of Reason

No summary of the exposition regarding Reason can be entirely satisfactory, for if the whole position be considered in all its circumstances we are inevitably led to a discussion of such amplitude as we have seen.

A partial résumé has already been given, but since then we have entered into a more elaborate examination of what is implied by Reason in complex examples, as in science, and we have observed what is meant by generalisation in such cases; and we have also inquired into the characteristics of a mind such as might help us to form a classification of minds according to a true standard.

It being understood therefore that indications, and not complete statements, are now offered, the results may be thus expressed:

Reason depends on the Fundamental Processes of the Mind. If any of these fail, as, for example, Immediate Presentation, or Memory, then Reason in regard to that particular fails. The due operation of the mind in a normal manner depends on the physical correlative, and therefore ultimately on the physical health and the whole physical disposition.

The Fundamental Processes are put in activity by stimulus through the senses, this term being used in its largest sense. Stimulus of notable importance comes from the external world. Such stimulus does not affect the mind as a *tabula rasa*.

The physical correlative of the mind, which must not be assumed to be the brain alone, is already prepared by its growth and stage of development to respond in determined ways to definite stimulus.

The origins of Reason are found in the modes of

action that have tended to the preservation of life. Instincts and the emotions and feelings associated with them form rudiments of Reason.

The growth and development of the physical correlative depend on factors which involve all the forces of the environment, and all those that may be grouped together as of heredity. In each individual the associations formed depend on the external world and on the physical base. The mind, and its physical base, must never be regarded as passive; they each represent rather a vast complex of forces held to some extent, though not entirely, in equilibrium.

A great proportion of the operations that affect consciousness lie beneath consciousness. The mind arrives at consciousness at successive moments, and discontinuously.

The progress of the mind is this: that the stimuli affecting it bring into activity the Fundamental Processes; and at each moment a new mental resultant, with correlative base (physical base), is formed; and this in turn determines the manner in which further stimuli are received.

Thus, while the Fundamental Processes remain constant, it depends on the constitution of the person and his environment what will be the complex of his mental operations and of his knowledge.

The schema of all the operations of a mind, and therefore of any mind, could be exhibited as built up of Fundamental Processes; the actual experiences determine how this schema shall be realised; and therefore in what way the knowledge of one person differs from that of another.

In this summary we speak for convenience of reference in such a manner as to imply a conception of personality (ego), of will, and of the external world,

but it will be shown in the course of the exposition how clear notions may be formed of all these by virtue of the Fundamental Processes.

In the exercise of the mind a certain Hedonic quality becomes manifest in regard to every particular operation. Associations are determined with more facility when this Hedonic quality is positive; that is to say, pleasurable. Hence it is that Agreement causes less disturbance to the mind than the contrary, Discrimination; and Association is less conspicuous than Disassociation.

By virtue of the Feeling of Effort, which is one of the elements on which Judgment is developed, and by virtue of Impulse, which is an element of Will, the mind has consciousness of its movement being determined. Hence each individual is enabled to say, I reason. (It will be seen, however, that the famous saying of Descartes, "Cogito, ergo sum"—I think, therefore I am—is an inversion of processes which are far removed from the fundamental.)

By the Process of Memory, associations, and therefore the most complex combinations, may be formed between ideas and Presentations.

But we say a certain course of Reasoning may be true or untrue. By true we mean correspondent to the course of Nature.

As, however, we deal with Nature in synthetic forms, and we observe frequent correspondences, or sequences, that are not invariable, it is evident that errors may arise.

Errors arise very frequently, and are indeed almost inevitable except in those operations in which, as in geometry, the appeal to experience is made at a level as fundamental as possible, and where at each step the closest regard is paid to the due functioning of the mind, ultimately in accordance with the Fundamental

Processes. Yet even in elementary geometry misapprehensions occur, and in the case of extended argumentation in geometry, many of the greatest geometers have been led into error.

Belief refers to an active condition of the mind where the resultant of the thought is felt to be in accordance with the invariable courses of Nature. The Hedonic sense is here manifested.

But there are many varieties of causes that may produce error in Reason, such as faulty symbolisation, and such as have been already discussed, and the failure may give no indication in consciousness.

The feeling of certitude in Belief is of no value as a criterion. It is often strongest in those minds least informed and least accustomed to deliberate. The sole criterion of Truth is to be found in the appeal to the course of Nature at the most fundamental level possible to our access. Even then there is no absolute criterion.

The only resource is found in testing incessantly the correspondence of our beliefs with the course of natural phenomena.

The conclusions found in exact science, as in geometry, are immeasurably more secure than those arrived at by untrained minds in the course of speculation in ill-defined regions.

What is spoken of as complexity in a subject has reference less to the actual nature of the subject than to the conditions under which our minds obtain cognisance of its complexity, and it may be roughly said to depend on the great diversity of the objects, on the operations of abstraction involved, on the difficulties of forming close associations, on the difficulties of Memory; and most of these difficulties may be summed up by saying, unfamiliarity. Therefore in such matters of thought constant exercise is necessary, practice in the details

of the subject dealt with, the use of aids to Memory, or, in default of that, good arrangement for constant reference and verification; and, above all, good systems of classification.

Classification as applied to external realms, such as in scientific work, is not a mere mechanical device. Classification implies the search for a principle of division. In order that the principle of division may be deep and valid, persistent analyses, and continued research in the realities of things, are necessary. This method of analysis, of generalisation, of classification, should be early adopted and so actively applied that it becomes the habit of movement of the mind.

From deep generalisation and classification, the mind should proceed to the consideration of their adaptation to particulars, and when any discrepancy is found, that should be the basis of new efforts of discovery. The scientific system should not dry the mind, and particularly should leave unimpaired lively apprehension, curiosity, activity, fancy, and imagination, and the great forms of energy implied in setting forth, after deep reflection, well-based strategic lines of research, and working these out with patience and resolution.

The mind should neither diffuse its energies too greatly, nor limit itself too much to the confines of what is called a "specialised" science, for the division of the sciences is artificial and in part unallowable. Aid should be sought from all sources, and particularly where technique is required care should be taken to secure skill and familiarity. Thus the microscope and the telescope really change the environment for us within the scope of their operations, and enable us to see into deeper correspondences and invariable sequences of Nature than would be possible without these aids.

Reason moves to the search of truth, and all prejudices, predilections, artificially inspired doctrines, if untrue, are inimical to the right use of Reason.

From all that has been said arises also the notion of the structure of the mind, as we might, in graphical language, call it. We find that the minds of highest structural development are those that move by seeking principles of generalisation in the most fundamental concordances of Nature; and we find also in the history of the world that such minds have been most fertile also of practical results.

There is now presented a conception of Reason very different from the dry and colourless series of processes into which it is generally analysed, or from the mere "chain of Associations" put forward by certain philosophers. We have the apprehension of Reason as a thing of activity and life, not merely drawing its stimulation or fund of knowledge from the objective province, but being really dependent on, though not dominated by, a thousand things of the wondrous order of the external world, from its most astonishing phenomena to the faintest intimations of existences not understood; and that these outside influences impinge on a mind of highly organised energy, and, in consequence, of great moving stability; and that to express the process of the formation of the instantaneous resultant, we must evoke complex images such as that of the magazine of stored knowledge, the influence of heredity, the sway of passions and emotions, personality, will power, the great moral qualities such as courage or those implied in purpose and the search for truth.

All these again are linked indissolubly to the physical basis. So that for the complete contemplation of Reason we have the spectacle of a complex of amazing and diverse activity, the Mind, associated in a manner not

in the least understood with the physical base, of which the brain forms a part, and cast into a certain environment from which it derives its stimulus and its real knowledge, the immediate environment being in turn a portion of a greater Universe alive with myriad forces of which our senses suspended in Space catch in restricted spectra only some selected few.

CHAPTER III

EXTENDED OPERATIONS OF REASON IN SCIENTIFIC FIELDS

§ I. Critical Examination of Scientific Results

It may be interesting now to examine closely the modes of reasoning in one or two examples of high scientific importance. We will consider the value of what is called the opsonic index in the treatment of cases of tuberculosis.

It is well, however, to refer, however briefly, to the history of the science of medicine in as far as bearing on this subject, so that the course of the argument may be rendered sufficiently clear even to those who have had no previous acquaintance with the terms.

Jenner in his investigations on small-pox became impressed by the observation that milkmaids were comparatively free from the malady.[1]

Investigation brought to light the fact that it was not uncommon to find that a milkmaid had had a sore finger, followed by physical signs and symptoms that suggested a mild case of small-pox. Under such circumstances also it was observed that the sores had been a consequence of touching similar sores on the animal, as in milking.

[1] The complete history of vaccination takes us back beyond the time of Jenner. It is Lady Wortley Montagu to whom is due the introduction to Western Europe of theories and practices of a rough mode of inoculation which she had observed in Constantinople.

The circumstances, except in regard to the mildness of the disease, bore such a resemblance to those of ordinary cases of small-pox that, associations leading the mind to generalisation, Jenner concluded that the milkmaid in question had acquired the small-pox, that these cases of small-pox were less virulent by reason of the infection coming from the cow, and that an attack of the kind made it improbable that the patient would be again attacked. From this observation it was an easy step to suggest that freedom or immunity from dangerous small-pox might be secured by vaccination; that is to say, by inoculating a person deliberately with the infective substance derived from the cow.

The notion of inoculation thus became familiar. By reason of the classification of diseases it was evidently no great step to suggest inoculation in other diseases, but the conditions of obtaining the infective substance, or what we now call the virus, were not so evidently presented.

The next decisive step was due to the researches of Pasteur, who proved in the case of anthrax in cattle that the disease was due to a certain bacillus; that it was possible to cultivate this bacillus; that it was possible also to render it less virulent by subjecting it to unfavourable conditions, as by inoculating animals, (guinea-pigs), and obtaining the bacillus again; that a milder form of the disease could be communicated to cattle by inoculation with the bacilli thus rendered less virulent.

Though the microbe of small-pox has not been demonstrated, the theory becomes easily suggested that the process there resembles that observed in anthrax.

In tuberculosis the bacillus has been demonstrated, therefore it required no great step to suppose that it would be well to adopt a method similar to that employed

in anthrax. Difficulties arise, however, with regard to the processes for rendering the bacillus less virulent, or, as it is called, attenuating the virus.

The next advance is due to Metchnikoff. He posed the problem: In what way is a disease overcome and eliminated from the system? He demonstrated that certain cells in the body, of which the white blood-corpuscles may be taken as examples, have the power of moving in the blood-vessels and elsewhere among the tissues, that these cells ingest them and so destroy the microbes. This action is called phagocytosis.

The problem of immunity must next be considered. In what way do the changes that accompany recovery from certain diseases render the subject secure, at least for a time, from a second attack? The question is not solved by pointing out the action of phagocytosis, for phagocytosis was present during the first attack, and was indeed the means of overcoming and eliminating the microbe.

We may, however, find it interesting to consider this question in dealing with the diversity of opinion that actually arose between Metchnikoff and Wright. Wright found that under certain conditions the resistance of a person to infection was increased. The resistance was shown by a greater activity of ingestion and destruction of the microbes. This was proved by actually examining under the microscope a large number of phagocytic cells, or phagocytes, and counting the microbes contained in them.

Metchnikoff, following a tendency which we have already noticed of extending, perhaps unduly, the scope of phenomena which have been especially studied (see pp. 391 *et seq.*), attributed the increased phagocytosis to increased power in the phagocytes themselves. He considered that they were stimulated by some new

substance entering the blood as the result of changed conditions.

Wright's investigations led him to suppose that the result was brought about not by stimulation of the phagocytes, but by rendering the microbes themselves less able to escape the phagocytes.

In what way could the question be decided? Wright adopted tests which were in accordance with good reasoning, but which would be available only to an experimenter possessing a mastery of technique (see pp. 405, 408, 412, and 421).

He obtained a suitable stock of white blood-corpuscles from the blood, keeping them in a glass tube of small calibre. He then obtained a stock of tubercle bacilli from a culture, and these also he kept in a small glass tube. He next obtained a certain quantity of the serum of normal blood. He then drew off a certain measured quantity, which would correspond to a certain number, of the white blood-corpuscles, and a certain quantity also of the tubercle bacilli. Then he mixed the measured quantities of phagocytes and bacilli in a certain quantity of serum.

Subsequently he examined the phagocytes under the microscope, and taking a number large enough to secure a good average, he counted the ingested bacilli.

For comparison he obtained a stock of phagocytes from the blood of a person suffering from tuberculosis. Then with this change he performed an experiment similar to the first, all other things being equal. He observed that the phagocytosis was equivalent to that of the first experiment.

Next he varied the conditions of experiment by using, instead of normal serum, the serum of the blood of the tuberculous patient, but with all the

other conditions similar to those of the first experiment. He found that phagocytosis had diminished.

Then the serum of a patient exceptionally strong in resistance at the time was substituted for the serum used in the previous experiment, but with the other conditions similar to those of that experiment. Phagocytosis was found to have increased above the normal.

This series of experiments demonstrated to Wright's satisfaction that the changes in the serum, corresponding to lessened or increased resistance to infection, affected not the phagocytes but the bacilli. The substances which change the character of the serum are hence called opsonins, from the Greek *opsonao*, I prepare a banquet.

We may defer the discussion of these experiments until we have considered a further step based on the theory so established. It is necessary to note previous experiments of Koch, who, in view of the fact that attenuated virus of the bacilli was not available, made use of a preparation from dead bacilli, which he called tuberculin.

Inoculation by tuberculin produced a "reaction." In some cases the "reaction" was so severe as to hasten the patient's death. In other cases the symptoms and signs of the reaction gradually subsided.

Wright interpreted these results as correspondent to the amount or efficiency of the opsonins in the blood. Thus where the effect of the inoculations by injections of tuberculin was to increase the resistance, the opsonins had increased in power and had rendered the bacilli an easier prey to the phagocytes.

In the cases where the patient's resistance diminished, the power of the opsonins had decreased even below that which prevailed previous to the injection. Hence the bacilli became more active.

In Koch's earlier experiments no accurate means had been employed to estimate the appropriate dose, nor was any method available by which the condition of reaction could be correctly ascertained in terms of increasing or decreasing resistance of the patient.

But when Wright had established his theory of opsonins, the next step was relatively not difficult. He had only to estimate the efficacy of the opsonins at intervals after the injection, and he had thus a clear indication of the progress of the reaction. Moreover, since the efficacy of the opsonins is estimated by an actual count of the bacilli found ingested in, say, a hundred phagocytes, there is obtained a numerical representation of the efficacy of the opsonins.

If, then, unity be selected as the measure of normal phagocytosis, an increased phagocytosis might be represented by 1·3, while a diminished phagocytosis might be represented by ·6. The opsonic index would be 1·3 in the first case, and ·6 in the second.

Now the object that the physician has in view is to increase the powers of resistance, if they be too low; and this increase is shown, by the method adopted by Wright, by an increased opsonic index. The physician may express the matter briefly, by virtue of that symbolisation which is at the base of all our reasoning, that his aim is to increase the patient's opsonic index in those cases where it is below the normal.

The next step involves less difficulty in reasoning than in the technique of the subject. It is necessary to ascertain in which way the opsonic index becomes affected by doses of tuberculin of various strengths, injected at intervals selected according to the purposes of the experiment.

Meanwhile, experiment and observation had suggested many changes in the preparation of tuberculin. Wright

found that much smaller doses than those originally employed were indicated. He discovered also that the usual sequence of events, with regard to the opsonic index, was that it showed a small initial fall of short duration, then a gradual large rise, and then a much more gradual fall.[1]

When the opsonic index reached the normal again, the time was appropriate for a new injection. A similar sequence followed. Therefore, if the dose of tuberculin were properly estimated, and the time of injection correctly determined by the opsonic index, the advantage to the patient was due to the opsonic index being kept above the normal for considerable periods as compared with those of the initial fall. Hence a net gain resulted.

Wright also found that if an injection were employed when the opsonic index was rising, the effect was to cause a sharp and prolonged fall.

These experiments indicated the errors of Koch's earlier method, and afforded a safer and more accurate means of employing the tuberculin preparation.

In the whole development of the subject that has led to the employment of the opsonic index in the treatment of tuberculosis, we have another example of the vast practical results that accrue whenever accurate observations, combined with a habit of generalisation, have enabled us to discover a secret of nature.

It may be well, therefore, to consider in some detail some of the steps of the process of development.

Jenner's original observation of the comparative immunity of milkmaids from virulent small-pox was first an association with some one milkmaid and immunity. But

[1] The usual explanation of these events does not take into account all the factors and is at best only hypothetical and tentative. An important lacuna here should be filled up by physiological and clinical observations in a great number of cases, and extending over longer periods of time than those hitherto considered.

the strength of this association depended on the associations already formed in the course of observation on the subject. The generalisation tentatively formed that milkmaids were less subject to virulent small-pox than others was found to be justified. That was simply a test in experience by a form of statistics.

Now this generalisation must imply classification. This implied association of agreements and also of Discrimination. And as the mind proceeds from Association to Association, a search is made amongst those of Discrimination for the grounds of association of milkmaids with immunity. Here, then, we come to observation, that is, to experience, with the intention of searching for some deep association corresponding to cause and effect.

Since small-pox is a disease that shows itself by eruptions on the skin, any sign of any sores or eruptions peculiar to, or unusually frequent amongst, milkmaids would attract attention. Then the origin of such a sore would be investigated. At length we should be led to connect the sore on the cow with that on the milkmaid's finger.

During the whole progress of this investigation the methods employed are those of the Fundamental Processes and their combinations. Consider, for example, the meaning of the term "observation." Here we have the Immediate Presentation of objects. Then we have Agreement and its inverse, Discrimination, which breaks the Units so presented into others. With each of these we have Associations formed in all manner of connections.

Then by new observed Agreements we have new Units formed by combinations proceeding from various Impulses, and leading to new Associations. All these processes are so familiar, and so rapid, and so automatic

that they escape the analysis of most of those who perform them, especially as by their familiarity they are for the most part indicated by symbols, and the whole scope of the associations of the symbols does not call forth attention.

Not only objects but acts often repeated become known as Units, become symbolised, and form their associations. Now, just as in finding one's way in the City to a known point, for example, the Monument, we continually form the association of our journey thither with that of each new association arising in experience; so, in a search for some indication regarding small-pox, we form, with all the associations that arise in experience, the association of a search for causes, consequences, or other associations with small-pox. In this way, and by disassociating all that seems to lead us away from our search, we direct our observation to (that is, by associations we form our course of experience of) the physical properties and acts that form in milkmaids a basis of Agreement between themselves and Discrimination from others.

The whole of our language is built up by symbolisations of objects met in experience, of acts frequently performed, and of those combinations of all of them which are so common as to require frequent reference. But it is well to show that such a symbol as observation may be reduced to terms of experience of the Fundamental Processes.

We find that the solution of the problem so far depended mainly on observation, but observation implying a great deal of work and good judgment (see pp. 332, 353, and 419). The progress is by a series of tentative generalisations which become tested by observation (see pp. 333, 340, 384, 397, 408, also 393, 394, 420). Thus it might at first appear that the

explanation of immunity from small-pox would be found in considering not the liability of milkmaids to disease, but some factors of their superior general health. They get up early in the morning, they take good exercise in the fields, they have good appetites, they eat nourishing food; they have not, as a rule, much worry derived from their work. But by considering other country-folk who were not specially free from small-pox, but whose general way of life was as healthy as that of the milkmaids, the investigator disassociated all suggestions arising from that side. Thus at length, by reason of the mind becoming freer to form fresh associations, after a series at first complex has been made familiar (see pp. 46, 344, 401, 412, 415, 416 *et seq.*), the investigator returns with renewed energy to the special features of a milkmaid's physical life, and he at length finds that the solution of apparent immunity resides in a special liability to disease. The explanation, he further observes, is that the disease so acquired is of mild form.

To those who think that the problem was really an easy one, it must be remarked that generations of physicians before the time of Jenner had sought all sorts of explanations for small-pox and had employed or suggested all sorts of fantastic remedies.

In our own day the cause of appendicitis is as mysterious as was formerly that of small-pox. All sorts of explanations are put forward, sometimes in quite a dogmatic style, but the fact that there are so many indicates that some of them must be wrong. Thus we have the prevalence of appendicitis, as estimated by the frequency of operations, ascribed to fast life, to drinking soda water, to using bread made by machinery, to riding in vehicles with pneumatic tyres, to eating strawberries, to over-study, to excess of alcohol, to orange-

pips, to the progress of surgery; all of which reasons may be found gravely set forth in medical writings.

We may now proceed to consider the processes of Reason involved in the further developments.

It will not be necessary to trace down the analysis of every process indicated by a symbol, for we have already considered how this may be done, but we may devote some attention to the steps that lay beyond ordinary observation.

Schwann's work, which was far more general in scope than that of Jenner, has already been referred to (see pp. 384 *et seq.*). It has the mark of genius in this particularly, that a study of apparently great complexity and difficulty of access was by a few simple experiments made to yield deep truths of amazingly wide application. Here we have an example of a mind accustomed to work determinedly by deep generalisation, associated with the skill acquired in laboratory practice (see pp. 405 *et seq.*, 408, 412, 421). Hence Schwann was able to test a theory that had remained a vague speculation with others.

Pasteur's work in anthrax involved much the same faculties as that of Jenner on small-pox. He was, however, already in possession of the germ theory which served him infallibly as a guiding line of Association. His work of observation was, nevertheless, more laborious, and in his investigations he not only observed actively, and long and patiently, but he questioned farmers, peasants, dairy people, all who could throw any light on the habits of cattle likely to be associated with anthrax. This observation implied formulating all manner of theories which he tested by concordance with actual experience. When Pasteur had at length demonstrated the anthrax bacillus as the cause of the disease, the next step towards finding

immunity was not difficult, for strong associations had already been created between small-pox and immunity, hence between immunity and any diseases which could be expressed in a classification containing small-pox.

Superior insight and superior energy of mind were required to produce the notion of preparing artificial conditions for the attenuation of the virus. The operation of mind is here at one point the inverse of that of Darwin's apprehension of the principle of Natural Selection. Darwin, impressed by the changes in structure produced by artificial selection, as in breeding pigeons, sought for an explanation of the phenomena in cases where this artificial selection could no longer apply.

Pasteur, familiar with instances of immunity from disease produced naturally, had to inquire in what way he could artificially prepare the necessary conditions.

These notions are not apparently so recondite to us as they might once have appeared; but they could only occur to a mind working determinedly and energetically along a certain line of research, so that extraneous distracting associations were excluded, while those that seemed to lead to a definite object came with a lively impulse and brought stimulus to the thinker's energy (see pp. 398 and 419).

Then the notion itself would have been without consequence in the mind of a man who had not acquired a grasp of technique, for the difficulties and complexities of the subject would have discouraged him.

Pasteur treated the bacilli to different temperatures so as to observe the most favourable and most unfavourable conditions of their activity. The suggestion arose through the deep generalisation by which he considered them, as he would have considered larger

animals familiar in natural history, with regard to their entire environment; and it was further necessary to consider in the widest generality the objects to which the symbol, environment, could be applied.

If now we proceed to the discussion of Wright's work we shall be impressed by the importance of a mastery of technique, for the difficulties that lay in his path were less those of suggestion of theories than those of the means of adequately examining them.

Metchnikoff had shown that our powers of resistance against invasions of microbes depended on the activity of the phagocytes. Therefore it might seem reasonable to say that increased resistance was due to increased phagocytic action.

But the fallacy here involved, at least with regard to the general principle, has been already discussed (see pp. 333, 391, and 448 *et seq.*).

The difficulty arises with the term "resistance of the system." It is only by observation and research that we come to recognise that this involves as one of the important features the action of phagocytes upon bacilli; but in elucidating clearly what is meant by the term we must have in view the whole process of phagocytosis. And when we consider changed conditions we must have in view also the whole process.

Part of the difficulty arises also from the impression of complexity which subjects present when expressed in unfamiliar terms and by a series of reasonings which present new terms, the full understanding of which is only known by continued analysis.

Therefore, if we exhibit a similar principle in more graphic pictures we may be able better to observe sources of error.

Suppose, for example, that under normal circumstances a combat between a force of Greeks and a host of

Persians would result in each Greek killing on an average three Persians.

Then if both armies arrived in a place where Greek wine was abundant, we might suppose that the Greeks killed on an average five Persians. To what should we attribute the difference? In such a case we might form an estimate by the manner in which the men respectively fought; but suppose we had no other means of gauging strength and skill than by the issue of the conflict itself. We would at least be careful not to assume that the whole difference was due to the increased vigour of the Greeks. In this case we would be aided by associations drawn from experience of cases which by a broad generalisation might be included in classification with the case considered.

To decide, we might experimentally arrange a combat between Persians who had had access to wine and a force of Greeks similar to the other, but who had had no opportunity of drinking. Suppose then that the result was that the Greeks killed on the average five Persians; we would infer that the Greeks fought just as well with or without wine.

Suppose now that under similar conditions, except in regard to wine, the Greeks, with wine, met the Persians who had had no wine; and suppose that the Greeks killed three Persians each on the average. Then we would conclude that the Persians did not fight so well when they had wine; and that the proportion of their fighting power compared to the normal was 3 to 5. Then $\frac{3}{5}$ might be considered as their index under conditions of the use of wine.

Having worked out the necessary conditions for ascertaining the influence of a new factor, the wine in the case considered, we easily adapt the results; by means of the observance of Agreement in the processes

which differ in the concrete objects illustrating the processes; by observing that these differences, moreover, may be covered under a symbol reached by a generalisation, as when the Greeks and the Persians, or the phagocytes and the bacilli, are spoken of as the two parties to the problem. Having generalised therefore the process applied in the first case we may take it step by step, changing the representatives of the parties. Therefore, having observed the action of the phagocytes on the bacilli in normal serum, and the action of the phagocytes on the bacilli in serum of a patient of lessened resistance, we must test the action of the phagocytes which have been formed in normal serum on the bacilli which have been under the influence of the serum corresponding to weak resistance.

We find by experiment, let us say, that the effect is the same as in the case where the phagocytes have been also subjected to the influence of the serum corresponding to weak resistance.

We now vary the last experiment by taking bacilli which have been under the influence of normal serum, and phagocytes which have been subjected to serum corresponding to weak resistance; we find that the phagocytic action is equivalent to that of the first experiment, where both phagocytes and bacilli were taken from those under the influence of normal serum.

Hence we conclude that the changes in the serum corresponding to weak resistance affect only the bacilli.

Various criticisms become now suggested.

For example, what is a normal phagocyte? It may be replied, a white blood corpuscle taken from the blood of a healthy person. But individuals of the human race, even when perfectly normal, differ widely in size, strength, and activity. It would seem therefore at first

sight probable that the white blood corpuscles would differ widely in their phagocytic capacity.

A great number of experiments, however, seem to indicate that white blood corpuscles, whether taken from young persons or old persons, weak or strong, show a remarkable constancy of activity. It must be understood, moreover, that when in the course of this exposition we speak of an experiment, we mean rather the type of experiment, for errors of observation are eliminated as far as possible by comparing a considerable number of experiments. The white blood corpuscle is also taken as the average of a great number of white blood corpuscles.

With these provisoes borne in mind we proceed to get white blood corpuscles from the blood of a normal subject. But the white blood corpuscles in the blood are to the red blood corpuscles in the proportion of one to five hundred; and we must also separate the blood corpuscles from the plasma which represents the liquid part of the blood, and from which its serum is derived by removing fibrin. Now the familiar process of the coagulation of the blood has been greatly studied by physiologists, and it is known that it occurs by the plasma being changed into serum and free fibrin, which becomes entangled with white and red corpuscles.

The ordinary process of coagulation is not satisfactory for the purpose now in view, for the white blood corpuscles become entangled in the fibrin together with the red blood corpuscles. This process of coagulation is therefore prevented by mixing the blood with a solution of citrate of soda. The process up to this point may be summarised thus:

Weigh out carefully 1·5 grammes of citrate of soda. Measure 100 cubic centimetres of distilled water. Dissolve the citrate of soda in the water, which thus

becomes of strength 1·5 per cent. Take a very small test tube an inch and a half long. Fill this with the solution to a level one quarter of an inch from the top. Prick the finger of the subject. Let the blood fall into the test tube so as to fill it up. Mix the blood and the solution.

But now to hasten the separation of plasma, white blood corpuscles, and red blood corpuscles, we "centrifuge." That is to say, we place the tube in a machine which imparts to it a rapid circular motion, the tube lying radially. This causes the separation of the white corpuscles from the other constituents to take place rapidly. The time required is about three minutes for a fast-driven centrifuge, but may be a quarter of an hour for a slow centrifuge.

The tube is then taken out and stuck in a saucer filled with sand. Then the supernatant fluid is sucked off by means of a capillary tube furnished with a teat, the manipulation of which produces the suction. This is a part of the technique which, though simple when once mastered, requires considerable practice.

The white and red blood corpuscles are now mixed up in the residue. We must now separate as far as possible the red blood corpuscles. This is an act which, though of considerable relative complexity, yet finds its symbolisation and its starting-point in the disassociation of two ideas. It is known from physiology that salt solutions act destructively on red blood corpuscles. Therefore the residue of the white and red blood corpuscles in the test tube is "washed" with salt solution, the best strength to use being ·85 per cent. Then the supernatant fluid is sucked off as before. Then, as a little detail of the technique, the test tube is generally inclined sideways, so that, as the white blood corpuscles are best found at the upper edge, a little

error of dipping deeply with the end of the capillary tube may not cause the white blood corpuscles to be mixed with anything else. A suitable quantity is then sucked off from the edge with the capillary tube. In this way we obtain the preparation we require of white blood corpuscles. It should be mentioned, however, that a pitfall of error has been found in the device of the inclined tube. It will be referred to afterwards.

The whole technique, to be executed with ease and certainty, requires practice. The process has depended on known results. So that finally the application of the symbol, "normal white blood corpuscles," has implied a considerable previous experience.

Even the technique of drawing off normal blood for the purpose of experiment requires some practice. A very small tube is used the end of which has been bent in a flame and drawn out to a point, which is then broken off, so as to leave a communication with the tube. It is not difficult to collect in such a capsule, as it is called, blood flowing from a pricked finger. There is a point of technique even in the pricking of a finger. The tip is chosen, and this should be perfectly clean. A piece of tape or a handkerchief is bound round the finger, so as to prevent the return flow of the blood from the finger. The finger becomes congested. A sterilised needle is then made to pierce the pulpy part, where the blood-vessels are most numerous. The little orifice of the capsule is then immersed in the flowing blood, and the capsule soon becomes filled.

The capsule is then sealed at both ends. The serum is obtained from the supernatant fluid after coagulation, and coagulation is hastened by putting the capsule in an incubator at a temperature of 37° C. The supernatant

fluid is then drawn off with the capillary tube. The serum of the patient is prepared in the same way.

The tubercle bacilli are obtained from a culture of tubercle bacilli. This symbol, culture of tubercle bacilli, covers in its implied classification many other symbols, which become analysed at length into a considerable complexity of objects and processes known in previous experience.

An emulsion of tubercle bacilli is prepared with 1·5 per cent. of salt solution. The strength of the emulsion is estimated by direct vision by what must be considered rough tests, as compared with the standards of precision usually aimed at by science. The solution should be turbid, but not thick.

The technique of the mixing of the tubercle emulsion, the white blood corpuscles, and the serum demands a certain skill of manipulation, for as the quantities are all small, the mixing is effected by means of the capillary tube provided with the teat. It is necessary first to calibrate, or graduate, the tube, not according to any given scale, but so as to measure off in the tube lengths corresponding to a given volume. This is done by drawing into the tube a certain quantity, or, as it appears in the tube, length of water, and marking its extremities in the tube. The water is then, by manipulating the teat, drawn along the tube, and its extremities marked in successive situations.

Then we know that the volumes included between markings of the extremities are equal.

Then the tube is used to draw up a certain quantity of white blood corpuscles; then a small bubble of air is admitted, and then an equal quantity, measured by the marks on the tube, of tubercle emulsion is taken up. A similar process is carried on with respect to the serum.

Then, by a pressure on the teat, all these quantities are expelled on to a clean glass slide, and so mixed. The mixed substance is again sucked up, and again expelled, and this process is continued, four or five times, until the mixture is fairly uniform.

The tube is then placed in an incubator for a given time, generally fifteen minutes. The next process is that of counting the tubercle bacilli ingested by the white blood corpuscles. But how is the count to be made?

Here again we meet with a symbol—count—of which the complete meaning can only be expressed by an analysis involving many objects and complex processes which have already been within our knowledge.

The count is made on a glass slide under the microscope. But as the whole number of the phagocytes and the bacilli cannot be counted, it is necessary to take an average. The only way available of taking an average of unknown quantities in this case is to obtain from the mixture a film of even thickness spread over the glass slide.

This is done by taking a quantity, a few drops, of the mixture on the slide, and then scraping it off with another slide held so that, while its edge rests in the first slide, it is drawn along that slide. The whole of the mixture cannot be scraped off; a smear is left which is taken to represent the average of the mixture. This part of the technique has also been modified. The best means now in use of obtaining an even film is to use a scraper slightly concave at the edges so that the centre part does not come into contact with the slide.

The slide is then stained by a process of which the object is to show the bacilli clearly in the white blood corpuscles. The stain is that used to identify the

tubercle bacilli in the first place, and there is nothing especially noteworthy in its application here.[1]

Even then the whole number of the white blood corpuscles on the slide are not taken into account. What appears to be a good part of the film is selected, and the bacilli are counted in the white blood corpuscles taken in a certain order, until a fair number, say fifty, or in some cases a hundred, of the corpuscles are taken. Then the total nunber of the bacilli counted is divided by the number of the corpuscles, so as to give the average for one white blood corpuscle.

A similar test is now employed, with the substitution of the serum of the blood to be tested for normal serum. The count is established as before. Then the ratio of the number obtained with the tested serum to that obtained with normal serum gives the opsonic index for the tested serum. Wright expresses the opsonic index as equal to

$$\frac{\text{phagocytic count of the patient's blood}}{\text{phagocytic count of the normal blood.}}$$

We may now interrupt this line of discussion for a while in order to discuss the meaning of complexity in such a case (see pp. 88, 140, 236, 340, 383, 389, 400, 410). Then we will consider some criticisms of the matter which may readily be suggested. Then we will regard the whole question in broader relations.

The series of operations described becomes so familiar to laboratory workers that it is performed with no sense of effort whatever—not even when, as often happens, errors are committed through faulty technique. Yet, at the first presentation, considering the entire method from the beginning, it seems complex.

[1] The question of staining is, however, of great importance to the whole method. Dr. Hans Much has demonstrated tubercle bacilli which are not "acid-fast." H. Dold ("Arbeiten aus dem Kaiserlichen Gesundheitsamte," 1911) has carefully considered the whole question.

It will be recognised that in this case also, as in other quite different fields (see pp. 410 *et seq.*), the impression of complexity is derived from unfamiliarity with objects and processes, with the difficulties of following a long series of processes without confusion due principally to failure of Memory, or to lack of Discrimination in too rapid a review. Then, since appeal has frequently to be made to results already known and stored up in the mind, the impression of complexity would arise if this acquired knowledge were badly arranged, as by faulty classifications (see pp. 141 and 389).

Complexity would occur also if this knowledge had not been considered so thoroughly and from so many points of view; that is, with regard to so many associations, linked in deep generalisations, that, when encountered again with unfamiliar superficial differences, the danger had become lessened that it should fail to suggest the proper associations. Practice producing familiarity removes all these difficulties.

Huxley said that there was nothing distinctive in scientific reasoning, that science only used the methods of common sense. This is true in so far, as we have shown, that every process of Reason in any field may be reduced in expression to terms of the Fundamental Processes.

But in a case such as we have considered we see that no argument could be conducted with one unacquainted with the terms, or the methods they symbolised. Further, since reference is made frequently to certain results, already established, and these are applied in new associations, it would be necessary to know of these results; otherwise the exposition would become at length a treatise on the subject involved, beginning at the foundation.

The man of ordinary common sense, unacquainted with science, is struck by the complexity of its reasonings, and it was the expression of this view that called forth Huxley's remark. Scientific reasoning is developed from common sense by directing it to objects classified according to a good system for covering a wide field; by storing up its acquired results by classifications which make them not only compendious but accessible to reference and suggestive in their associations; by making all observations and records as accurate and precise as possible; and by being continually progressive in well-directed effort.

But we have in these terms expressed the general principle of Evolution, and if the theories which Huxley advocated in that matter be true, it is to Evolution that the difference is due even between a man and a horse. Huxley's remark should be modified accordingly.

Moreover, it must always be borne in mind that though every example of Reason may be reduced to expression in terms of the Fundamental Processes and the objects of experience, yet by virtue of the uncertainty of those objects of experience it is difficult to express formally the scope of any problem. We have seen that even in geometry something is assumed from experience more frequently and in greater measure than is definitely stated. In dealing with phenomena the assumptions are larger and more difficult of proof.

Thus calling phagocyte, P; normal serum, N; serum to be tested, T; and bacilli, B; we might say

P + N	acting	on	B + N	produces result	R
P + T	„	„	B + N	„ „	R
P + N	„	„	B + T	„ „	r
P + T	„	„	B + T	„ „	r

Therefore the difference of results is due to the difference of N and T as affecting B.

But in reality we cannot make this sharp distinction, for when we take white blood corpuscles, or phagocytes, which have been subjected to the action of a patient's serum, and bring them into contact with bacilli which are then under the influence of normal serum, we change the conditions of the activity of the corpuscles. The corpuscles may find a new stimulus in the very fact of fresh contact with normal serum.

It may be asked whether the process necessary to obtain a quantity of white blood corpuscles does not greatly alter the characteristics they display in the blood itself. That may be so, but the test after all is not between the white blood corpuscles so obtained and those in the blood, but between normal serum and the serum to be examined. We are therefore less concerned with possible changes in the white blood corpuscles than with the necessity of their giving fairly constant results in the conditions under which we use them.

This constant character of the white blood corpuscles, as well as the constancy of normal serum, and the constancy of the emulsions of tubercle bacilli, may be tested thus. We institute a series of experiments with a certain sample of normal serum: then institute other series with other samples with the same emulsion and the same stock of white blood corpuscles.

If then within reasonable degrees of divergence we find the results agree we declare that normal serum is constant.

Thus if we took the results from the first serum as 1, and found that the opsonic index for any other normal serum varied only between the limits ·8 and 1·2, then we should have reason to be content, for

the serum of tuberculous patients is found to show, if several tests be made, wider divergences.

Normal serum is generally obtained by mixing the serum of several, say half a dozen, persons in ordinary good health.

Next having ascertained the constancy of normal serum, and having ascertained also by similar means the constancy of the emulsion of tubercle bacilli, we may change the origin of our white blood corpuscles. It is found by actual experiment that white blood corpuscles from most varied sources show a remarkable constancy of constitution and activity.

The statistics given by Dr. Alexander Fleming, a pupil of Wright, are notable in this respect.[1]

But this discussion still leaves the efficacy of the method a matter of debate.

The results obtained by Fleming, with regard to the constancy of the white blood corpuscles, even from diseased sources, are so contrary to what might have been expected prior to this evidence, that one is tempted to ask whether a sufficiently large number of experiments have been undertaken to eliminate accidental sources of errors, and coincidences. Moreover, the "personal equation" as it is called, that is to say, sources of error due to the idiosyncrasies of the experimenters, should always be eliminated by a sufficient number of controlling tests of other experimenters.

Then again there is no part of the method that does not require some experience; and at crucial points some judgment of selection is demanded. For example we have twice a selection of averages from the results of phagocytosis; once in obtaining an even film to represent a few drops of the mixture, which

[1] See the *Practitioner* for May 1908.

drops, again, represent the whole mixture containing the serum, the bacilli, and the white blood corpuscles; secondly, in taking a certain relatively small number of white blood corpuscles in the film to represent the whole number.

It is very important to examine with the most scrupulous care every incident of the technique, for as we are not dealing with quantities precisely defined, errors are bound to arise. If, then, the probability of an error were at any one step x to 1, and at the next step y to 1, then taking both steps the probabilities would be xy to 1. Consequently in a process involving many steps small probabilities of error multiply to something considerable.

We have found that the white blood corpuscles are relatively constant; but we have in our preparation of white blood corpuscles many things to consider besides this original constancy.

Thus the following sources of error may be cited in regard to the white blood corpuscles alone:

1. The exact volume may not always be taken up in the capillary tube. This source of error is not very important.

2. Air bubbles taken up in the mixture make the count irregular. Good technique should avoid this.

3. Violence in mixing may injure the white blood corpuscles. This source of error is apparently minimal.

4. The variation of the time of incubation. This source of error is eliminated by always taking the same time. Small accidental errors are negligible.

5. The technique of the inclined tube, which was thought to afford the best means of taking up the white blood corpuscles in the capillary tube, was found to be occasionally a source of serious error, for the salt solution was never wholly removed, and this diluted the prepara-

tion of white blood corpuscles; consequently the number of white corpuscles was not always the same for the same quantity taken up by the capillary tube. It has been found preferable to shake up the white blood corpuscles with the red, and take up an even mixture of both.

6. Mixing with red blood corpuscles may produce serious errors in cases where the red blood corpuscles become agglutinated or stuck together. The consideration of this question opens up an extensive field of technique.

7. The origin of the white blood corpuscles, from healthy or unhealthy persons, is not a matter of indifference, but the constancy is much greater than one might expect.

8. Serious differences are observed if the white blood corpuscles are obtained at different times and in different ways.

9. The centrifuging affects the white blood corpuscles. Different rates of speed and different periods of application cause errors.

10. The freshness of the white blood corpuscles is a matter of importance.

With the bacterial emulsion we have also several sources of error:

1. Uneven suspension of the bacilli in the emulsion produces error.

2. If the salt solution used in making the emulsion be weaker than 1·5 per cent., the results are not quite reliable.

3. The length of time during which the bacilli have grown in artificial culture affects the results seriously.[1]

4. Agglutination of the bacilli would cause important

[1] Cf. note p. 13.

errors, but this may be avoided by previously heating the bacilli to 100° C.

5. Sometimes the bacilli ingested do not show up in the count, because they have not taken the stain well. Errors so caused might be serious.[1]

There are other sources of error in connection with the serum.

1. The presence of red blood corpuscles in the serum is a possible source of important errors.

2. The length of time which has elapsed since the serum was drawn affects the result; after a week the difference may be considerable. The variation is, moreover, irregular.

3. If air be allowed access to the capsules containing serum, the quality of the serum becomes changed, and after some hours the change is important.

4. The capsule may be over-heated in sealing it.

5. The temperature at which the serum is kept is of importance.

With so many sources of errors, and with these errors having a multiplied importance, it is not surprising that the results obtained by different observers vary so widely as to deprive the method of much of its usefulness.

In foreign countries the method has been criticised adversely. Hans Much, a German authority, Director of the Department of Experimental Therapeutics in the Eppendorfen Hospital, goes so far as to question the interpretation of the ingestion of bacilli by the phagocytes; and he therefore joins issue with Metchnikoff as to phagocytosis being the chief, or even an important, defence against bacterial invasion. Some American authorities have condemned not only the technique, but the whole theory of opsonins. A pupil of Wright, the

[1] Cf. note p. 470.

late J. H. Wells, in a series of special experiments, found: "The anti-bacterial defence in children cannot depend upon the opsonic content of the serum." This is one of those disconcerting conclusions, already referred to, which indicate the necessity of a revision of the whole theory until the source of the discrepancy becomes manifest.

It is partly on account of these divergences that we have chosen for discussion the question of the opsonic index. For here we see a subject investigated by the finest scientific means at our command in such a field, serving also to illustrate a technique which at many points wins our admiration, allowing its methods and its results to be indicated step by step, repeating its experiments a hundredfold, inviting criticism and examination in every incident of its progress, producing consistent and highly valuable results in the hands of some, and yet failing to convince others equally sincere in their desire for valid results, and even producing in the minds of a few a feeling of doubt upon the preceding results which had led to its suggestion, and which had been considered established (see pp. 347 *et seq.*).

The causes of the discrepancies of opinions may now be considered. They must eventually be referred to the Fundamental Processes. These are functions one of the other (see p. 35), but we may make certain distinctions, as when one of these processes becomes presented in the forefront of our regard.

In order to discuss the question at all, we must make use of Memory. A solitary student thinking over some problem of his own may fail because his Memory does not serve him in recalling the exact terms of a formula, or the exact incidents of some scientific process. Such a failure of Memory is here out of the question, for with the number of workers who have with great interest

examined this question, any lapse of Memory on the part of one would be immediately brought to book by the criticism of others.

Moreover, since it is a problem of which the alleged demonstration is presented to our criticism, it is of the nature of those discussed previously (pp. 320 *et seq.*).

The question of seeking tentatives by Impulses at each point leading to new Associations is not here in view; for that would mean finding a new solution to this problem, or a new problem altogether.

The sources of error will be those of the failure of Discrimination, and of the group of Generalisation, classification, symbolisation, and of the wrong employment of Association arising from imperfect knowledge of the symbol.

Thus for example we find errors similar to those already discussed (cf. pp. 350 *et seq.*) where a symbol covers a Classification, a, b, c, d, e, and where having observed a, b, c, d, we proceed to the full associations of the symbol. We have a case of the error of Impulsive Association.

Take the symbol "white blood corpuscles." We may question its constancy with regard to phagocytic power; we may question the exactitude of the volume with which we experiment; we may question the effect of centrifuging, and the violence of mixing. But being reassured on all these points we are inclined to accept the symbol as expressing, for the purpose of any one experiment, something known and constant.

It required, however, not only considerable experience in laboratory work, but also definite experiments, to bring to light other associations connected with the symbol, such as e, f, g, to be added to a, b, c, d (see above). Thus it was long before the technique of the inclined tube (cf. p. 471) was suspected.

Advantage therefore in throwing light on the process of reasoning has been gained by the detailed exposition of the sources of error.

But we have considered such sources of error, some of them unexpected, but all exhibited with meticulous care by the experimenters who have observed them. The Impulse becomes then almost irresistible to proceed now in the belief that such examination is complete. But suppose a question arose as to the constancy of the white blood corpuscles in some conditions of disease in which their numbers are greatly increased in the blood, or even as to the temporary considerable increase of the "leucocytic tide," after a good meal. We should have to examine such cases. Then we might in the future discover sources of error not yet clearly perceived.

But other sources of error are those of Complex Classification; such as we have already considered, where a symbol A is defined by a, b, c, d, and when d, for example is defined by another classification, and so on till we reach the term which has been only vaguely defined, or which has been accepted with incorrect or ambiguous definition.

Thus we speak of an emulsion of tubercle bacilli. The term emulsion requires definition, for we have seen that sources of error are to be found in uneven suspensions in the emulsion, and the employment of weak salt solutions in its preparation. Moreover, we have no exact standard for estimating the emulsion.

If we consider, then, the term tubercle bacilli, we find that for the recognition of the tubercle bacillus we rely on a process of staining with carbol fuchsin and treatment of the stain subsequently by sulphuric acid. So that the tubercle bacillus is at length placed in the classification of microscopic organisms that stain with carbol fuchsin and which are "acid-fast," that is which retain the stain

after a stream of sulphuric acid has been poured over it. From other such acid-fast organisms it is differentiated by other tests.

The process of staining involves questions of technique which are of great practical importance. We have seen also (cf. p. 473) that inefficiency of staining may produce errors in counting.

The process of examination under the microscope for counting implies also an acquaintance with the technique of the microscope which can only be acquired by special study followed by some practice.

So far, dealing only with the question of the identification of the tubercle bacilli, we have met with complexity; but within the limits of what may be acquired in regard to technique, we have not found ambiguity or vagueness.

But when we deal with cultures of tubercle bacilli the case is different. How do we know in what respects the bacilli of a culture differ from the bacilli found in the human body? The bacilli used for cultures have no doubt come originally from the human body, but they are subjected to new conditions, and we know that in course of time important changes in their condition take place in consequence. How do we know that the bacilli of the culture represent fairly well, even for the purposes of our experiments, the bacilli of the patient?

It may be said that the bacilli of the culture are only used to test the serum. That is true, but it is also true that we desire to test the serum in order to obtain indications of the influence of the serum of the blood of the patient upon the bacilli of the patient, with relation to the phagocytic activity, under these conditions, of the white blood corpuscles of the patient; whereas we are really testing the phagocytic action, under changed general conditions, of changed white blood corpuscles, on changed bacilli, influenced by changed serum.

The fact of results being consistent with themselves under these conditions proves nothing regarding the objection just presented. On the contrary, the consistency of results under conditions wherein consistency was not to be anticipated may make us suspect some source of error.

The constancy of normal serum, and the constancy of white blood corpuscles drawn from very different sources, deserve particular attention. May not the changed conditions account for the apparent constancy? We may give a graphic example, which must not be taken for an argument, but only for an illustration of the general line of thought in considering such a question.

The Athenians normally kill three Persians each in combat. The Spartans normally kill five each. But suppose that the combat takes place in a dense fog, which depresses all parties alike, but that the comparatively helpless Persians are in such numbers that the Athenians and the Spartans have no difficulty in killing those they fall in with. It is possible that they could kill six each on the average. But this constancy could not thereupon be imputed to the ordinary case.

What is the importance of the changes we are not able to demonstrate. It may eventuallybe shown that the effect of the changes is not serious in regard to the applications to the human system. But in any case the onus of the proof of this rests entirely with those who ask us to accept the theory of the opsonic index.

What the discussion has proved is not only that the symbols employed rest on a long series of classifications upon classifications, but that in certain of the terms thus met with the classification is vague, that is to say, we are here liable to the error of Complex Classification.

Another source of error is this, that even if the principle of the technique be granted, there will arise differences of judgment concerning its application.

Let us take an illustration referring to another science. In quantitative analysis in chemistry an important point in the process is determining when a certain solution changes colour as a consequence of another solution falling into it drop by drop.

Thus the estimation of the amount of sugar dissolved in a litre of water might be ascertained by a process of which the main steps are here given: 34·639 grammes of copper sulphate are dissolved in 200 cubic centimetres of distilled water; 173 grammes of Rochelle salt are dissolved in 600 cubic centimetres of a 14 per cent. solution of caustic soda. These solutions are called respectively Fehling's solution No. 1 and Fehling's solution No. 2. The two solutions may be mixed. They are diluted to a litre. It has already been ascertained in chemical science that dextrose (which is a form of sugar) will reduce the cupric hydrate, which becomes formed in Fehling's solution, as we may now call the mixture of the two solutions No. 1 and No. 2; and it is also known that 0·05 gramme of dextrose reduces the cupric hydrate contained in 10 cubic centimetres. Reduction is a chemical change, about which we are not at present so much concerned as we are with regard to the indications that it has occurred.

10 cubic centimetres of Fehling's solution are now taken and diluted with 40 centimetres of distilled water, and then boiled in a white porcelain dish.

A portion of the water containing the sugar in solution, diluted if necessary, is introduced into a burette, which is a long tube provided with a narrow orifice and other arrangements, so that the water may be made to flow, when required, drop by drop. The burette is

calibrated so that it is possible to read off immediately from its scale how much water has flowed from it through the orifice.

The water from the burette is run into the dish containing the boiling Fehling's solution, until the blue colour of the copper solution disappears. This change gives the indication that all the cupric hydrate is reduced.

We know then that the quantity of water run in from the burette contained 0·05 gramme of sugar, because it has reduced the cupric hydrate contained in 10 cubic centimetres of Fehling's solution.

We now ascertain from the scale of the burette how much water has been run in; and as this quantity has contained 0·05 gramme of dextrose, we can by a simple proportion calculate how much sugar was contained in the litre of water.

The technique of this process is not difficult. A skilled operator can obtain results within 2 per cent. of error. But even intelligent students, accustomed to perform chemical experiments, often produce errors quite surprising in amount, even up to 20 per cent. or more, in estimations of the quantity of sugar.

One difficulty is that of Discrimination with regard to the disappearance of the blue colour, although when an expert is operating the matter looks simple.

But this is not the only point at which Discrimination is necessary. The reason why practice produces efficiency is that at every step Discrimination is required not only with regard to visual objects, but with regard to manipulations and co-ordination of operations. We have seen in what way practice aids Discrimination.

I have chosen this illustration because the phenomena involved in it are striking, and they are also more familiar than those of bacteriology. But the principle

of Discrimination applies no less importantly in all the steps of the complex process for obtaining the opsonic index.

Fleming himself speaks of the "judgment" required in counting. That is but an instance of Discrimination. The difference between the work of an expert and the work of a beginner, even one familiar with the manipulation of scientific instruments, would be enormous. This indicates that by practice not only the sight, the touch, but complex co-ordination of actions that derive indications from various senses, become more precise by reason of Discrimination.

The measure of accuracy of a process, however, should be estimated in reference to those who are competent to use it. Thus if a quantitative analysis of sugar be faulty in the hands of any person, we do not take it that the method itself is faulty, but simply that the person has not acquired the necessary proficiency.

The criticism with regard to the assumption that these processes in the test correspond to the processes in the body is unaffected by the possible accuracy of estimation. The divergency found in the results even by skilled workers indicates, moreover, that the method is only of use in the hands of specially trained experts, and that in ordinary cases the estimations are likely to be misleading.

Leaving now the discussion of the opsonic index we may cast a glance over the general field. That is to say, instead of considering the demonstration offered by a certain problem, we may pose as the main problem the cure of tuberculosis and seek solutions (see pp. 486 *et seq.*).

In the case of small-pox we endeavour to immunise the patient beforehand; but in the case of tuberculosis

we have to deal with a patient already affected. The problem here involved leads inevitably to that larger question of the science of bacteriology, What is the natural history of the microbe? What is its mode of life? What are the "optimum" conditions in their fullest expression? What are the most disadvantageous conditions? If these questions could be answered, we would ask, How can we in the human body avoid certain conditions tending to benefit the microbe and produce those tending to destroy it? These matters would necessarily be considered in relation to the general health of the subject, and thus we are introduced to the field of medicine. On the basis of a deep classification we might pose the problem:

What are the means at our disposal for combating the microbes, derived either from the resources of all kinds of our system (Internal factors), or derived from something added purposely to our systems (External factors)? Then in further subdivisions we would inquire whether reactions such as we have described are the only internal resources. In answering this question we may have an extensive field opened up.

In regard to external factors we have to deal with a subject which has already become vast and complex—serum-treatment; then that of medicines, as, for example, of quinine or mercury in certain cases in which such drugs act as specifics; then we have a long category of other treatments.

A full consideration of the matter would also lead us to the study of the natural history of the white blood corpuscles, and hence we are introduced to the wider, fascinating realm of the "cytologist," or student of cells.

As part of the problem, again, we should ask, What are opsonins? At present we know only of opsonins

by their action, in conjunction with other constituents of the blood, on the microbes with regard to their defence against phagocytosis.

In a wide generalisation we find here a point of agreement with the supposed microbe of small-pox, which we have not seen, and of which we know only that it causes small-pox. This microbe may eventually be discovered by means of research more refined, but on lines similar to those by which various other microbes have been successfully demonstrated.

Also opsonins may be demonstrated eventually by researches on the lines of those which have enabled us to detect other constituents of the blood, as for example by delicate chemical analysis.

The question arises also as to the origin of opsonins. It seems reasonable that they must be a product of cells, even though not of the phagocytes as some have supposed, because the whole human body is built up of cells. The only other hypothesis would be that they were derived from things in the body, but not a necessary part of the body.

Then one would inquire, supposing they were the product of cells, in what way were they derived from cells, whether by secretion, by excretion, or by decomposition, or by some form of recomposition.

Within more limited scope, however, it may be asked whether it would be possible to find attenuated cultures of tubercle bacilli which when inoculated would produce an acute phase of the disease, but within the limits of control, so that the reaction of the system would result in the elimination of the bacilli which had already gained entrance. Observing, moreover, that the reaction in Koch's treatment is produced by adding fresh toxins to a system already overcharged, at least locally, it might be asked whether it would be possible, by massage

or exercise, to produce similar effects by utilising the infection already present.

The difficulty in such a case would be to control the amount; and from that point, as from others, we are led to consider clinical indications of reactions to the bacilli or their products.

Wright has himself considered this question in detail, and he has in some cases suggested suitable clinical tests, but he has concluded that in other cases clinical tests would be unavailable.

Here is a possible field for a statistical method of inquiry (see p. 400), for if a record were kept of the opsonic indices, and at the same time of a complete list of physical signs and symptoms, it is possible that indications from some of these, or combinations of these, might be valuable. The more fundamental way of answering the question would be to inquire what is the real character of reaction; that is to say, what are the total changes of constitution it implies, as, for example, changes in the blood; and in all these what is the sequence of cause and effect.

Reviewing what we have observed in the course of study of the theory of opsonins, we find that every operation may finally be expressed in terms of the Fundamental Processes. We have seen a wide field of science, which is now being explored with great energy, of which the practical results are of great importance. Yet some of the consideratious have been shown to be abstruse, as, for instance, when the symbol "opsonin" is applied to something undetermined, and manifested only in its reputed effects.

We have met with examples of elaborate technique, long consecutive movements of ratiocination, and of the use of imagination in science; yet in any one particular we may rapidly descend to the Fundamental

Processes, and we may retrace the route and observe the building up of knowledge.

A problem which was first presented as belonging to the biological domain may demand for its solution more research in chemistry, new discoveries in physics, consequently finer development of the mathematical apparatus, and thus eventually may be affected by clear views in the realm of psychology.

Finally, the veritable solutions of many of these matters may arise, not by pursuing the paths that have suggested the problems, but possibly by some deeper insight into natural phenomena, comparable to the strokes of genius of Schwann by which with simple means he established generalisations of enormous scope.

A question of method in reasoning here also arises. We considered, by means of an analogy, the proof of the effect of the opsonins on the bacilli. The use of analogies is, however, misleading, for in order that a proof by an analogy may be valid, it is necessary to indicate in what way the example offered differs from that in question, and we must be able to show that the demonstration is not vitiated by the differences. But if we do all this then we have considered the original case in all its circumstances, and we have added the consideration of a case foreign to the matter in hand.

Yet it may happen that an analogy is useful both for the understanding of a question and for the exposition of a complicated subject.

We have already seen in the discussion on complexity that the difficulty arises from having to hold the attention to a great mass of facts of which the relations are not clear, and of which the associations are not deep.

An analogy helps us to free the mind from a number of details, so as to give it more freedom and to keep its

energy more intact. Subsequently we may return and make the corrections due to the details omitted. That is, however, a step which is often forgotten. Hence arguments from analogy are often fallacious, and in cases where the particulars of difference are themselves complex and important, as, for example, in analogies drawn from foreign countries, errors are inevitable.

In its proper use analogy is a temporary expedient depending on a special generalisation demanding particular note of the associations and disassociations necessary, and the transference of symbols.

In the example considered the analogy of the Persians and Greeks may well be misleading, for, as we have seen, there is in the case of the phagocytes and the bacilli no means of completely disassociating them from the medium (serum corresponding in the analogy to the wine) in which they move.

§ II. Considerations not merely Critical, but referring to High Speculative Qualities, Plans of Research, and Methods of Verification

If we would consider another problem of great interest, and of vast complexity, which also affords ground for discussing possible errors of reasoning, we may select one of the latest developments of Biology: Experimental Parthenogenesis. In this discussion we will not refer so persistently as in that on the opsonic index to the Fundamental Processes. We have already shown in a subject of great abstraction, mathematics, that every mental act involved was either one of the Fundamental Processes (see p. 213), or could be analysed so as to be demonstrated as compounded of such Processes. In the discussion of subjects having

more obvious concrete Presentations, such as our references to bacteriology, we have seen that all mental acts involved could be referred ultimately to the same Fundamental Process.

We have also shown that when the concrete objects by which a Process is illustrated become changed, there is no change in the character of the Process itself (see pp. 213, 341 *et seq.*). It will be therefore easy to observe in the following discussion of biological problems that every mental act involved can be referred to the Fundamental Processes.

But it is not convenient, nor even scientific, continually to make such reference. For example, in mathematics the whole science is built up by the symbolisation of combinations of processes. Certain complex arrangements of factors with the expression of relations between them constitute formulæ, and the development of mathematics has been due to the facility by which these can be referred to as known results.

In every kind of reasoning we find combinations corresponding to these formulæ, and it is only when some particular feature of these calls for discussion that I will in future indicate the analysis.

If in considering Experimental Parthenogenesis we base our comments on the work of Prof. Yves Delage at the Zoological Station at Roscoff, we shall find numerous lessons in classification. In no other way than by the habitual use of good classification could order be shown in such an extensive subject.

The problem might be posed thus: Is it possible, and if so, in what way is it possible, to arrange conditions, apart from the action of spermatozoids, so that certain ova may develop which are incapable of developing by themselves under ordinary conditions?

We may first select the organisms with whose eggs

we intend to experiment. We are then introduced to the classification of the organic world. Many of the representatives we would reject as unsuitable, because in a case of the kind it would be indicated to begin with simple examples (see p. 185).

A review of the subject shows that experiments of the kind under discussion have been made by various workers throughout a considerable range of beings, from vegetables to amphibians.[1]

The most striking experiments of Delage were in echinoderms, of which he selected sea-urchins as the most suitable. As to the selection of agents for promoting the process of parthenogenesis, the experimenter might pass in review all those that have been found to have, or that seem likely to have, any influence in cell development of any kind.

A classification would be here necessary, as, for example, into (1) Mechanical agents, such as friction, shaking; (2) Physical, such as change of temperature, electricity; (3) Chemical, as, for example, various solutions added either to sea water or to fresh water.

In this case, as in the history of all sciences, we find that at the threshold a great deal of work had been done by various biologists, experimenting with a great variety of ova, and by diverse means.

Loeb had already obtained an experimental parthenogenesis of the eggs of sea-urchins, but he had not been able to preserve the new organisms up to the adult stage.

[1] Since Delage's work on *Echinodermata* Prof. Bataillon of Dijon has been brilliantly successful in the case of animals so highly organised as frogs. His method was to select an egg just about to be laid and prick it with a fine platinum needle. The eggs were then placed in water. Segmentation occurred, and in 2 per cent. of the cases he obtained tadpoles. Prof. Bataillon gave an account of his work to the Académie des Sciences in April, 1910. Since then he has obtained the results just mentioned.

The study of Experimental Parthenogenesis has resembled that of other natural sciences also in this, that associated with close observation of the effects of experiments, and the nature of the process itself in as far as it is accessible to observation, we have had a number of theories tentatively put forward and examined. A few of these theories may be here referred to.

Loeb believed that the essential agency in producing fecundation was that of supplying to the egg certain molecules charged with electricity. He sought to produce a similar effect by the employment of a solution rich in potassium or magnesium, so that the appropriate ions, as the molecules charged with electricity are called, might find their way into the egg.[1] This was in 1899.

Loeb, searching in various directions for explanations, but with the guiding notion already indicated, thought that ions, such as those of sodium or calcium, might have an inhibitory effect on the process, and that part of the action of the chemical substances employed was to dilute these ions. Many considerations infirmed both these theories. The egg is not relatively deficient in magnesium. Moreover, it has never been demonstrated that the magnesium ions from a solution penetrate the egg.

It has also been found in this science, as in so many others, that similar hypotheses have been emitted by different biologists independently, or that the minds of biologists have been prepared to accept readily certain theories.

Yves Delage in 1900 called attention to the fact that

[1] W. A. Shenstone, in "The New Physics and Chemistry," says: "Charged atoms are called ions"; and a little later speaks of "ions, which are atoms, or groups of atoms, carrying one or more electrons." The New Chemistry has not reached any definite conclusion as to the nature of an atom or of a molecule. Here therefore I use the term in a wide sense.

in the natural process of fecundation the egg is dehydrated; that is to say, it parts with water.

Bataillon, about the same time, having made observations in osmosis in connection with the egg (see p. 403), concluded that before fecundation the egg was in osmotic equilibrium with the sea water, but that by adding certain salts to this water it was rendered "hypertonic"; that is to say, in such a condition that in the process of osmosis water passed out of the egg.

Loeb adopted this theory of dehydration, but he believed also that the particular chemical solution employed exercised a specific action; but later he considered that the principle of dehydration by osmosis was sufficient.

Delage, however, obtained Experimental Parthenogenesis with "hypertonic" solutions; that is to say, solutions which by osmosis gave up their water to the egg. Loeb obtained similar results under similar conditions.

Various theories occupied attention until 1903, when Matthews announced the hypothesis that the chemical agents producing Parthenogenesis were those that liquefied the protoplasm of the egg.

In 1906 Loeb, observing that hypertonic solutions were inefficacious in the absence of oxygen, supposed that the action of these solutions in producing Parthenogenesis was that of oxidation.

This was only an hypothesis to be tested. It had no sufficient validity for a theory. Thus, if we have in one body a complex of properties a, b, c, d, e, it is but a guess to ascribe any particular action to a. If a could be isolated, one could test the accuracy of the guess. If the action took place with a body having the complex z, b, c, d, e, then it would be evident that a was not the agent

Considerations and tests of this kind did not confirm the hypothesis of oxidation.

The question as to specific action of chemical solutions—that is to say, whether the chemical nature itself of the solution had any influence on the process—was tested by Delage.

He arranged so that without varying osmotic action he introduced under similar conditions diverse chemical solutions, and he found varying results accordingly. The percentage of successful experiments was highest with sulphide of soda and chlorate of nickel.

We may now consider another aspect of the question. The examination of this biological question has already involved that of chemistry. But in the hypothesis the question of ions has held a prominent place. The theory of ions involves that of electricity, and also an extended conception of chemistry as it has been worked out on a physical basis by the researches and demonstrations of great chemists, who are also great physicists, of whom Van t'Hoff was one of the pioneers. So that this biological study may involve an immense range of co-ordinated studies (see pp. 190, 386, 396, 402, and 409).

The study of ions involves that of the true meaning of solution. The investigation of that subject led Raoult to highly interesting researches on the boiling point of liquids, on the freezing point, and on the depression of vapour tension due to substances held in solution.

Van t'Hoff united these results with those obtained by new studies in osmosis, by which he was led to the luminous remark that a body dissolved in water was really in a gaseous state.

The question of osmosis involves that also of the substance through which the osmosis takes place. The study of osmosis has evidently an intimate bearing on

the subject of Experimental Parthenogenesis, for we have the conditions directly presented: the egg with its membrane; the surrounding liquid with its chemical substances in solution, and in most of the experiments in a hypertonic state.

Moreover Delage, in seeking for a theory which should give him a less tentative method of working, was led to make a close study of the theory of ions. The study of ions, joined to the microscopic observations of the physical characters of the egg, suggested theories accounting both for the stability of the egg and the changes that take place in development.

This is a subject on which a great number of biologists—Lillie, Gallardo, Leduc, Perrin—have made observations, performed experiments, and conceived theories. In many of these the notions put forth are attractive and ingenious, but they are not convincing.

There is no certainty that all the factors have been taken into account, and in organic processes the co-operating factors may be numberless. There is no rigorous proof that the effects follow from the causes indicated, and there is no means of excluding the action of other causes. Necessarily the whole of the reasoning is thus liable to the error of Intricate Classification (see pp. 369 *et seq.*).

Delage observed that nearly all the phenomena of cell division could be classified under the headings of (1) displacement of particles; (2) dissolutions, or resolutions of substances into granules; (3) coagulations. The dissolutions and coagulations are found to be alternate. The displacement of particles may be regarded as the agent for these alternate dissolutions and coagulations.

A discussion of the order and manner of the successive dissolutions and coagulations would imply a

preliminary study of the striking phenomena of cell-division. Suffice it here to say that Delage, having reached this generalisation, and observing, moreover, both the regular succession and the intricacy of the phenomena, became impressed by the suggestion that these actions were not due to the continual intervention of an external agency, but were part of the intrinsic working of the system of the egg; in other words, that once the operation was set in motion, each successive condition of the egg provided the factors for the next change.

The eggs have developed along the same lines for countless generations, and there thus becomes formed a chain of organic associations. Delage thought that if it were possible to start the process, it would continue by virtue of its intrinsic conditions.

This led him to consider that the action of the reagents hitherto employed had depended on their coagulating and dissolving powers. Further tests, therefore, were directed towards discovering the best substances for this purpose, and the best manner in which to employ them.

After many trials Delage found that the best results were obtained by the use of tannin, as a coagulating agent, for five minutes in the water surrounding the eggs, following this by the addition of sal ammoniac as a dissolving agent.

As a consequence of this procedure, Delage obtained, for the first time in history, a fully developed sea-urchin by Experimental Parthenogenesis. At one time he had seven of these creatures, but after a lapse of some months only two remained. The largest of these had, before the end of 1908, reached a diameter of two-thirds of an inch. Both were active, in good health, and living a life apparently quite normal.

It must not be concluded, and Delage himself does not conclude, that because results have been in accordance with the theory put forward, this theory is necessarily correct. In the employment of chemical reagents, and in the whole scope of the reaction between the egg and its circumambient fluid, a great variety of forces are called into play, chemical and physical, a, b, c, d, e. Now all these may be requisite, and if we attribute the result to a, b, c alone, then, according to a classification already suggested, we may say that the error is that of Impulsive Association (see pp. 352, 386, 398). But a, b, c may have nothing to do with the matter as cause to the effect, which may be due to d, e. In this case the error would be that of Involved Association.

The problem of Involved Association may be dealt with thus. Suppose that we have certain results produced by a, b, c, d, e; a, l, m, n, o; a, w, x, y, z; it is evident that no one of these combinations is the ultimate cause.

The common factor in all is a, but it does not follow that we should be right in attributing the effect to a alone. A very simple example will make this clear. A number of people, a, b, c, d, e, get on to a weighing machine, weighted to 50 stone, and as a consequence the lever is raised. Then while a remains, b, c, d, e are replaced by l, m, n, o; the effect on the lever is repeated. A similar result is obtained when the people are a, w, x, y, z. But we cannot conclude that if a alone remained on the machine the lever would rise.

In all series of the kind the combination itself introduces a new factor. Nevertheless it may happen in certain cases that a is the sole cause of the phenomena. The test in such a case is to isolate a and observe if the result previously obtained follows.

Delage observed that Experimental Parthenogenesis was produced by a great variety of chemical reagents, and it occurred to him to test whether the phenomena were due to a factor common to all. This factor he considered might be the electricity in the ions corresponding to the chemical compound. He therefore resolved to test the effect upon the eggs of charges of electricity applied without the intervention of the chemical reagents at all.

In the memoir "La Parthénogenèse Electrique," in the *Archives de Zoologie Expérimentale et Générale*, 1908, in which Delage gives the details of his experiments, he remarks: "It cost nothing to try."

But to those unaccustomed to deal with such questions the difficulty of the technique here presented would be deterrent. The apparatus actually adopted by Delage was a new arrangement, but it was a combination of arrangements with which previous experience had made him familiar.

The problem of technique resembles on the manual side that of ratiocination on the mental side. The complexity of a problem we have seen depends on the unfamiliarity of the objects and processes involved, and on the extent of the acquired knowledge necessary to which reference is made. Practice, by giving familiarity, makes a process formerly complex appear simple. Similarly with technique, the difficulty consists in the want of familiarity with the apparatus used, and with the necessity of having by practice acquired expertness in a great number of manipulations and co-ordinations of movements as applied to the apparatus.

But as a mathematician familiar with formulæ solves problems differing to some extent from those he has been accustomed to, so an experimenter in biology

finds it easy to adapt his methods to a new case, even though some invention be required.

We have had occasion to compare the processes of ratiocination in abstruse subjects with those of every-day life, and we have found that the vast fund of things which we have made familiar are great in proportion to that generally added in special subjects, and it is in accordance with this view that we find technique also of some complexity in subjects not considered scientific. Thus a Yale footballer invents the plan of the "flying wedge." The suggestion itself is not recondite, especially to any one who deliberately sets out to devise new methods of forcing a way through the resistance of a rival side of about equal strength. But the difficulty consists in arranging it practically, and this would be impossible to any one who could not experiment with trained players.

General Baden-Powell in his book, "Aids to Scouting," says: "I have seen such a man look almost horrified with a 'what-am-I-to-do-with-this-lot?' look on his face, when given a live sheep and a helmet full of flour as his ration for the next four days." He was face to face with a problem of which the technique was the difficulty, and the vernacular employed was due to the impression of complexity (see pp. 405, 408, 412, 421, 458).

Having thus looked at the question of technique in more general relations we may return to the problem of Delage.

The apparatus employed by him consisted of a sort of dish formed by fixing an upright circular rim of glass to a bottom plate of mica. Below the mica was attached a thin disc of tin covering the whole extent of mica on this under aspect.

The dish was now filled with some liquid in which

the eggs were placed, so that they could sink to the bottom and rest on the upper surface of the mica. The liquid employed by Delage consisted of a solution of saccharose, with a mixture of sea water and salt solution. He now connected the liquid with the positive pole, and the tin disc at the under surface of the mica with the negative pole, of a battery of twelve Leclanché cells in series. By this arrangement the system of the mica plate and the liquid and the tin disc became a condenser.

The eggs resting on the mica were thus submitted to the action of electricity, but without a current.

The positive pole was connected with the liquid and the negative pole with the tin for about thirty minutes; and then by means of a commutator this action was reversed, and the negative pole remained in connection with the liquid and the positive with the tin, for about an hour and a quarter.

These were the conditions which gave the best results.

Delage obtained numerous larvæ, but none of these developed into the adult stage. The conditions of the experiment were such that it could not be affirmed that there was not a feeble current of electricity, and the effects may have been due to this, and not to the electrification of the electrolyte at the surface of the mica with which the eggs were in contact.

Some further experiments of Delage indicate the systematic way in which he proceeded by classification. He had usually made use of tannin as the coagulating agent, but to assume that the effects were due to tannin might be to commit the error of Involved Association (see p. 494), for tannin nearly always contains impurities. Delage therefore experimented with diverse tannins from different woods, but the results varied

very little. He therefore concluded that the tannin itself was the agent to which the effects were due.

The results obtained by Loeb and Delage, prominently amongst other biologists, have been combated by others not by examining point by point their arguments and their methods, but by reason of a general principle of the supposed impossibility of vital processes of nature being thus produced experimentally.

This attitude of mind is not wholly unscientific, at least in as far as it may lead to an hypothesis. Certain bacteriologists, for example, believe that the whole series of the experiments is vitiated by some error of Involved Association. They are accustomed to find profound effects produced by organisms which are often extraordinarily hard to demonstrate even when we deliberately search for them in the way in which we should find them, as by means of microscopic examination aided by staining. Some of the organisms whose effects we know have never been demonstrated at all. There may be a suspicion that in this experimental parthenogenesis some unknown agency has co-operated as in the case of ordinary fecundation. Delage has been careful to meet such objections. He established control experiments, in which all the conditions were present except those of the agents which he had selected for testing.

The utmost care was taken to free the solutions used, as well as the eggs themselves, from any natural agent of fecundation.

Moreover, the course of events was not that observed in natural fecundation, for the usual phenomena of the extrusion of the two polar bodies from the eggs were not produced, only one polar body being extruded. The sea-urchins obtained experimentally also, although

healthy and active, were not, as is usually the case, built on the pentagonal system, but on a regular hexagonal system.

All these considerations have led Delage to exclude the possibility of natural fecundation having taken place in some hidden way.

If now we review the preceding discussion we find certain salient features that seize the attention. One is the manner of growth of science, bearing out again the dictum of Graham: "Follow Game" (see p. 402). The force of this saying is here strikingly shown if we consider that the very first suggestions that led ultimately to the experiments of Parthenogenesis seemed to have little relation to it.

It was known that if the heart of an animal be placed in a solution of salt it may continue to beat for hours, although if placed in sterilised water it soon ceases to beat. This observation suggested many studies of the action of saline and other solutions on animal tissues, and these studies ultimately led Loeb to the conclusion of the possibility of Parthenogenesis. His experiments were at length brilliantly successful, and those of Delage carried the results still further.

Every experiment carefully noted and recorded, even if unfruitful in view of the expected result, is of interest, and may indeed offer suggestions of greater value than the hypothesis on which it was founded.

Another feature shown in review is this: That the progress of science is aided by the habit of seeking deep generalisations in the particular instances observed, that these generalisations lead to careful classification, which again suggest new particular instances derived from the generalisation.

It seems also that the sources of most frequent error are Involved Association and Intricate Classifi-

cation. Both of these may depend on the difficulties of technique, with the enforced limitation of Discrimination.

The necessity of continual practice to ensure good technique is indicated. The growing demands on other sciences, as the science itself grows, is shown; hence the inefficacy of too narrow specialism.

Finally, amid certain acquired results we are face to face with the uncertainty either of the rigour of our processes or of the fundamental causes of the phenomena observed.

§ III. Consideration of Hypotheses and of the Difficulty of Excluding Error

Illustrations of errors in reasoning are so numerous that the whole history of the human race might be written in these terms. Locke said that it was hardly possible to invent an error that had not been at one time adopted as truth.

What we have already discussed has prepared us to accept such a remark, for the progress of all individual reasoning is that of a series of tentatives afterwards tested in their applications to realities.

These tests in the earlier condition of development, when activities were mainly devoted to the question of subsistence, were of the nature of those solved in the problems of survival of the fittest.

Later, when men began to speculate more widely, their task was enormously difficult by reason of the complexities of the subject and by their having few or erroneous resources in the form of knowledge already acquired (see pp. 386 *et seq.*, and 398 *et seq.*).

The difficulty of pioneers of thought is indeed not so much that of having no well-established points of

reference, but rather that their minds have been already warped by all manner of false influences.

The state of doubt in regard to problems is in itself disagreeable (see p. 377), and this is not the less marked in regard to complex, important, though not immediately pending, questions. The state of doubt is more irksome to minds ill informed and untrained than to superior minds. Hence the pioneers of thought have always been face to face with errors of Authoritative Association (see p. 357), errors of Impulsive Association (see p. 352), errors of Intricate Classification (see pp. 368 *et seq.*), often intermingled with other errors in tangled confusion.

When material interests have been based on errors, and when strong associations of men have been formed in any manner for the defence of these interests, or where emotional associations have created predilections or prejudices, then errors have become organised into the very modes of thought; and it has required something beyond skill in ratiocination to secure advance in truth (see pp. 292, 348, 358 *et seq.*, 364, 381).

But it is not only in ordinary minds that striking illustrations of errors in reasoning may be found. Genius, even in the domain of regions of thought, has given no exemption from errors of reasoning in other fields. Consider Descartes, whose work is more than a monument of human greatness, for it is veritably one of the factors of our civilisation itself. This refers to his mathematics, for otherwise his philosophical speculations were unfortunate. Yet, even though the product is so strange, Descartes may be looked on as one of the pioneers of physiological psychology, for his philosophical reflections led him eventually to the study of anatomy, and particularly of the constitution of the brain.

Descartes was struck with the bilateral symmetry of the brain, which seemed to him complete except in one part, the pineal gland. Now modern researches have reached the very curious and unexpected conclusion that the pineal gland is not part of the brain substance, properly so called, at all, although it is enclosed within the skull. It is an embryonic residue corresponding to a rudimentary third eye found in some reptiles.[1]

But Descartes, proceeding from the supposition that the brain was the organ of thought, concluded that a single part situated between the two corresponding parts must be the seat of some faculty evenly balanced with regard to the two sides. Hence it was not difficult in this style of reasoning to arrive at the conclusion that the pineal gland was the seat of the soul, which from that point of vantage could direct the thoughts to one side or the other.

But in what way can the soul be supposed to sit in any definite situation? And what is the nature of the thoughts that can be thus directed by the soul stationed in a certain place?

Descartes departed from his own analytical method when entering the domain of psychology, and his conception of the soul sitting in the pineal gland as an arbiter is grossly materialistic. But Descartes is often quoted by idealistic philosophers in support of their views. One of these which I have met with recently struck my attention as much from the peculiar style of reasoning as from the pompous language employed: "Ask him whose genius it was that con-

[1] In Lacertilia the apex of the pineal gland is transformed into an azygos eye. It was in studying Hatteria that Baldwin Spencer discovered the secret of the pineal body. It there appeared at the surface of the skin and retained distinct traces of an eye-like structure.

ceived and produced the indissoluble alliance between the doctrines of Number and Space, brought together the sundered hemispheres of apodictic thought and thus created the world of Analytical Geometry."[1]

The argument is that Descartes was therefore a very wonderful man, that therefore his authority is exceptional even on subjects apart from "apodictic thought," and that therefore the writer's views are correct in as far as they have a sanction from Descartes. But this line of argument would just as well bring us back to the pineal gland again.

It is the error of Authoritative Association into which Descartes himself continually falls in his discussion of psychology (cf. p. 357).

This error is a favourite weapon with rhetoricians. An appeal is made to the fame of a certain popular personage, and then a transition is made to the acceptance of some position which the famous person held, and the proof is implied in the statement.

Thus at a time when Disraeli was a more famous man than Darwin, he was thought by many to have extinguished the thesis of "The Origin of Species" by an epigram—that between the ape and the angel he would be on the side of the angels.

It may happen, however, that occasionally the error is applied in the reverse way. That is to say, a man of science may be quoted for his opinion on some question of politics or art in which he has no competence.

A general concordance, for example, with the Synthetic Philosophy of Herbert Spencer need not imply agreement with the opinions of Herbert Spencer in matters that have no direet connection with the Synthetic Philosophy. His article on Style deals with the subject too much from the standpoint of convenience of reading. But in dancing,

[1] Cassius T. Keyser in *The Hibbert Journal*, January 1909.

for example, the sole object is not to get to the other side of the room; while Alpine climbing, again, though arduous, has a fascination for many, and part of the pleasure consists in the climbing itself.

With Herbert Spencer's *Man versus the State*, we may agree, or disagree, or form eclectic opinions of agreement and disagreement; but we cannot regard it as a corollary from the Synthetic Philosophy.

The Middle Ages, amid a civilisation which was so wretched a derogation from the old Greek ideal, yet clung to one error of Authoritative Association derived from the Greeks; for the doctrines of Aristotle on all subjects of science were regarded as so sacred that it was a revolt even to test them by experiment. A glimmering of a new civilisation began when Galileo disproved Aristotle's notions about falling bodies by showing that a small object and a large object fell at the same rate from the top of the Tower of Pisa.

One of the cases where this error, and errors of all kinds, are abundant is where in political arguments one country is cited as an example to another. It may be that the question has arisen of autonomy to a certain country and both the advocates and the opponents cite analogies and parallels from the conditions observed elsewhere.

But the history of any country is hardly ever rightly understood by a foreigner; that is to say, with such an understanding of the course of events that the due motives and the actual forces producing the results are beheld with absolutely sure appreciation. History is usually written in the style of display, as if one should describe a steam-engine knowing nothing of its real principles, but being attracted by its picturesque adjuncts.

Here then we have already the errors of False Symbolisation, Impulsive Association, Intricate Classi-

fication. Thus in comparing one country with another, there should be shown either correspondence of conditions or a full exposition of differences with the proof of the limitations of their effect.

This is never done. Were it possible to do this, it would be easier to reason convincingly on the basis of the country in question itself without the use of these analogies (cf. p. 485).

Here then we have the error of False Generalisation. But we may seek more closely for the ground of this False Generalisation.

The review of the question not being available with an appreciation of all its factors, we find that it resolves always into the discussion of some point which may not be essential. Here we have the error of Repercussive Association (cf. pp. 358 *et seq.*).

Another curious instance of Authoritative Association is the triumph it gives a partisan in any discussion if he finds he can quote Shakespeare. The reasoning implied is this: Shakespeare is the great national poet; everything he has written, or possibly even that one of his actors may have interpolated, has some superior meaning or insight; therefore, even in subjects which Shakespeare had never particularly considered, his word is law. Apropos of this, John Stuart Mill tells rather an amusing story in his Autobiography. His father, James Mill, a severe logician not very strong on the æsthetic side, thought little of Shakespeare. He advised John, however, to make himself familiar with quotations from Shakespeare, as he recognised how effective they were in debate.

The authority of Newton, so great in questions of Mechanics, is often invoked in matters for which he had no special aptitude (cf. pp. 365 *et seq.*, 391, 410).

Newton said that there was no great difference in

the ability of different persons, and that his own success was due to perseverance and application.

Yet one of the most striking conditions with respect to persons is that of the great disparities observable. First of all, in every factor on the physical side there are great divergences on both sides of an average type. It is reasonable, therefore, to expect that in combinations of these the disparities will be multiplied.

No amount of training would have made Byron a ballet dancer, or Newton an athlete capable of swimming the Channel. We see every day in games that a man who has devoted years of his life, say to cricket, is beaten by some one with exceptional aptitude who may not have spent half so much time in practice.

In mental qualities, which, moreover, have always a physical base (cf. pp. 95 *et seq.*, 235, 373, 419), the divergences are greater, for the scope is larger and the combinations more complex.

Even the question of perseverance and application is not settled in the mere terms of forcing of the will (cf. pp. 234, 390, 419, 422). The problem involves the irksomeness of toil, which itself is relatively greater in one than in another, and also the amount of stimulation. Stimulation is derived to some extent from a clear view of the consequences of effort, and that depends on intelligence directed towards a goal.

Further, the factor must be taken into account of the absence of distracting pleasures absorbing time and energy, and this presupposes either the absence of the corresponding faculties, or intelligence and will-power to keep them in due restraint (cf. pp. 410, 421).

There must be taken into account, also, the intrinsic energy of the individual, his tastes—which depend on a multitude of factors—his courage, and his whole general character.

But it is all this precisely that constitutes the difference between one person and another. Not every boy that attended his village school with Newton could, even by trying hard, have discovered the law of Gravitation.

High authority should never deter us from the search of possible causes of error even in those subjects where that authority has been justly attained. In such cases the criticism must indeed be persistent and keen, for the errors, if existent, are bound to be deeply concealed. On the other hand any departure from actual demonstration, say in biological subjects, is likely to involve error, for the conditions are complex and our imaginations and inventions hitherto have yielded but unsatisfactory accounts of Nature's processes.[1]

Let us consider some examples.

Tyndall, following Helmholtz, put forward a bold hypothesis concerning the functions of the organ of Corti, which is one of the parts of the auditory apparatus. The matter requires a little preliminary explanation. The whole auditory apparatus forms a very complex system, the object of which is that the undulations of the external air produced by the vibrating of bodies may within certain limits be represented in impulses to nerves which convey their message to the brain.

The tympanic membrane, or drum, of the ear is moved by the air waves. The impulses are conveyed from the tympanic membrane through a series of little bones to the inner ear. The function of the ossicles of the ear is said to be that of diminishing the amplitude of the movements of the tympanic membrane and increasing

[1] It seems somewhat paradoxical to quote an authority against the misuse of authority, but the following words of old Sir Thomas Browne have a savour of their own: "The mortallest enemy unto knowledge, and that which hath done the greatest execution upon truth, hath been a peremptory adhesion unto authority, and more especially the establishing of our belief upon the dictates of antiquity."

their power, but it is probable that other uses are also subserved by the whole arrangement of the drum and the little bones.

At the inner ear, the inner of the little bones, the stapes or stirrup, is inserted into a small oval opening in the inner wall of the tympanum. This opening is called the *fenestra ovalis*, or oval window. The stapes is attached to its margins by a membrane. We will afterwards trace the course of an impulse from the stapes through the internal ear.

The internal ear consists essentially of a membranous sac, derived from involuted epithelium of the embryo, but in the course of development it has assumed a complicated or labyrinthine shape. It fits into the bone, which has a correspondingly labyrinthine form to receive it. The sac itself is filled with a fluid called endolymph. The bony labyrinth contains perilymph, which is thus in contact with the membranous sac.

The bony labyrinth is formed from before backwards by the cochlea, so called from its resemblance to the spiral form of a snail's shell, the vestibule, and the semicircular canals.

The cochlea, when well developed, is about an inch in length, measuring along its spiral turns.

It is divided along the course of the spiral into two parts, the *scala vestibuli* and the *scala tympani*, which are continuous, however, at the apex. Between these is the spiral of the membranous sac, or, as this portion of the sac which is in the cochlea is called, the duct of the cochlea. This is roughly triangular in section, one side being formed by the basilar membrane, separating it from the *scala tympani*; the other side, by the membrane of Reissner, separating it from the *scala vestibuli*; the third side is in contact with the outer bony wall.

The duct of the cochlea contains the essential part of

the organ of hearing. The organ of Corti consists of a double row of stiff, rod-like cells, the outer and inner members of the series resting on the basilar membrane, but uniting together at their other extremities. These rods support, on each side, rows of hair-cells which are connected with the terminations of the auditory nerve.

The basilar membrane, which is composed of elastic fibres, stretches from a projecting ridge of the central column of the cochlea to the opposite wall continuously throughout the length of the spiral. At the apex a communication is allowed between the *scala tympani* and *scala vestibuli* by an aperture called the helicotrema. The length of the fibres forming the basilar membrane increases from about $\frac{1}{600}$ of an inch at the base to about $\frac{1}{60}$ of an inch at the apex.[1]

Vibrations of air which strike the tympanic membrane are transmitted through the chain of ossicles to the *fenestra ovalis*. Corresponding agitations are thus produced in the perilymph. These are conducted by the perilymph of the *scala vestibuli*, and so onward through the spiral to the apex, when they are communicated to the perilymph in the *scala tympani*, and so on to its termination at the membrane of the *fenestra rotunda*, or round window, which closes an aperture of the wall of the inner ear on the same aspect as the *fenestra ovalis*.

Helmholtz suggested that the basilar membrane was the apparatus by means of which, for example, a chord struck on the piano could be analysed into its constituent notes.[2]

[1] Cf. Starling, "Elements of Human Physiology." Hensen, who is the original authority, gives for breadth at the base, 0·041 mm.; near the helicotrema, 0·495 mm.

[2] Alfred Denker has published an important study, "Die Membrane basilaris im Papageienohr und die Helmholtz'che Resonanztheorie," *Biol. Centbl.* 1906. He finds new puzzles in regard to the Helmholtz theory, in the small number, the irregular change in length, and the sinuosities of the fibres in the case of the basilar membrane of the parrot.

Here we have a case of a generalisation suggested by a comparatively superficial Agreement. If a chord be struck on a piano, and tuning forks corresponding to the notes be placed in the vicinity, then each tuning fork will vibrate as if its own note had been struck separately.

The fibres of the basilar membrane increase in length, and as the pitch of a note of a violin depends on the length of the string, so the different lengths of the fibres of the basilar membrane were considered to correspond to different notes.

The supposition that this generalisation has been suggested by a superficial Agreement should not imply that the generalisation is wrong; but the proof is so loose as to be liable to all sorts of errors, especially that of Intricate Classification, at every turn. It is true that we can trace the course of the external impulse till it produces the impulse given to the perilymph; further, in the communication, by means of this impulse, of a stimulus to the endings of the auditory nerve, the basilar membrane seems by the physical conditions to intervene as an important agent.

But even if the basilar membrane vibrated like a drum, communication would still exist by reason of the community of the perilymph of the *scala vestibuli* with that of the *scala tympani*; and also impressions could be communicated to the endolymph in the membranous sac through the membrane of Reissner.

The theory of Helmholtz could not be considered established until a demonstration had been given of the exact manner in which the perilymph was thrown into agitation by reason of the sound waves; then the demonstration of the effect of this agitation step by step upon the whole apparatus of the membranous sac, so as to explain its complex development.

Moreover, in considering these questions we must

not necessarily look for undulations as the definite stimulus of the ends of the auditory nerve, for the sensation of sound is not the same thing as a vibration, and we do not know in what way we obtain a sensation from the stimulus of a nerve-ending, nor what is the character of the change in the end organ corresponding to the sensation.[1]

In the case we have been considering various objections have been raised to the theory of Helmholtz. It has been pointed out that there is not enough difference in the lengths of the fibres of the basilar membrane to represent the differences of the vibrations of the air corresponding to the range of sounds.[2] Ewald therefore suggested that the whole basilar membrane vibrated but with nodal points of the fibres. The variety of the stimuli thus given to the nerve-endings would correspond to the variety of sounds.[3]

Another theory supposes that the basilar membrane vibrates as a whole like a telephone plate. The analysis of notes is in this theory considered as a function of the brain.[4]

[1] Dr. G. Arbour Stephens has published an article, "Colour Vision in its Relation to other Senses," in which he puts forward the theory that sound waves alter the conductivity of visual impressions. Without necessarily accepting this the mind becomes awakened to various possible factors not contained in the hypothesis of Helmholtz.

[2] If this be taken in connection with Denker's work referred to in a previous note, the objection is indeed formidable. Dr. Albert Gray has modified the theory of Helmholtz ingeniously (*Journ. of Laryngology, Rhinology, and Otology*, 1905), but in truth the objections should take deeper ground and display a more diversified aspect than that referred to. For one thing, experiments are needed to show the effects of vibrations of air on liquids in tubes.

[3] Ewald's theory was supported by some delicate and beautiful, but not conclusive, experiments.

[4] Rinne and Voltolini put forward this theory, and Rutherford afterwards advocated it. The weak point is the lack of evidence. Max Mayer has still another, imagined to account for differential tones derived from tuning-forks. It is notable in that it endeavours to trace the wave along the perilymph, but it is faulty in that the character of this movement is only surmised. Cf. also Lord Rayleigh, "On the Perception of the Direction of Sound," *Proc. Roy. Soc.* 1909.

The diversity of these theories illustrates the possibilities of error in scientific subjects even among thinkers of a very high level of intellect.

The name of Helmholtz is also associated with a theory of vision, which, however, originated with Thomas Young. This theory proceeds from the observation that all colours can be formed by combinations of red, green and violet.

Young supposed therefore that in the retina were found sets of three nerve-fibres, which responded respectively to the stimulation of red, green, or violet light. If two or three of these nerve-fibres were stimulated simultaneously, then the sensation would be something different to that corresponding to the stimulation of any one nerve-fibre.

Here we have an hypothesis formed on the suggestion of the effect of mixing the primary colours; but in order to demonstrate the theory it would be necessary to show that the end organs of the visual nerves in the retina really do present such an arrangement, and that this arrangement could only subserve the purpose indicated. Even then there would be mysteries in the problem of vision; for in what way, we might ask, do the effects of the separate stimuli become combined?

The theory illustrates the use of Imagination in science; but as we have seen in the case of Milton's "Paradise Lost," Imagination of this sort gives often a very ineffective picture of the reality. Generally it seems better to create than to interpret, but not when the work is the Universe itself. The fault is not that the man of science is too imaginative, but that he is not imaginative enough (see pp. 393, 394 *et seq.*, 408, 420).

He forms his imagination from a survey of Agreement within too narrow a scope, and upon the associations

which have occurred to him in too limited experience. It is true that in Nature we find a great diversity of objects fashioned according to the same fundamental model; but the variety of the objects is immense, and in any case it is often only through deep generalisation that we can hope to reach the Agreement expressed in the principle of structure of related organisms (see pp. 386 and 411). In the case of the organs of sense our knowledge of the mechanism is very imperfect.[1]

That Young's hypothesis has not been established is indicated by the fact that Hering has found it necessary to invent another.[2] He classifies primary visual sensations relating to colours in three groups, red and green, yellow and blue, white and black. Corresponding to these groups he considers that there is a special substance in the retina. A sensation of red corresponds to the process of using up, or katabolism of this substance; a sensation of green corresponds to the reverse process, anabolism of the substance. Similar conditions hold good with respect to yellow and blue. The white-black substance is not only affected similarly by the disturbances corresponding to white and black, but also by red and green, or yellow and blue. Most of the phenomena of colour vision may be explained, plausibly at least, by either the Young-Helmholtz hypothesis or by that of Hering.[3]

For instance, if in mixing colours on a pallet a certain shade be produced, one has in the Young-Helmholtz theory only to imagine each colour as being formed of

[1] See note, p. 511.

[2] Von Kries has still another theory, proceeding really from the original suggestion of Young, but making the combination of elements a function of the central not of the peripheral part of the nervous system. There are various other theories. Cf. J. Bernstein, "Eine neue Theorie der Farbenempfindung," *Naturwiss. Rundschau*, 1906, and an article of E. V. Tschermak, *Lancet*, 1909.

[3] Hering has recently revised his original theory entirely ("Die Lehre vom Lichtsinn," 1909).

the colours red, green, and violet in certain proportions; then the resultant colour will also be formed of these three in certain proportions.

In the Hering theory the process is similar, but it must be noted that red and green together, for example, producing a destruction, and a restoration, of the corresponding substance, would have their effects neutralised, while their effects on the white-black substance would persist.

Cases of colour blindness (see p. 310) when red is indistinguishable from green may be explained upon either theory.

It is said that the Young-Helmholtz theory fails to account for cases where the colour blindness is complete, that is to say, where colour rays give the impression only of light and shade. On Hering's theory one could say that the functions of the red-green substance and the yellow-blue substance were suppressed.

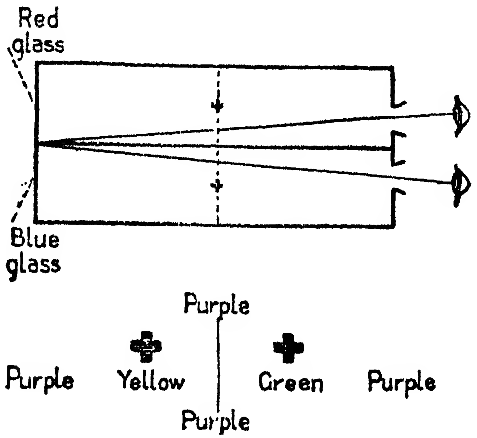
But it is quite possible to account for the conditions also on the basis of Young's hypothesis. Since there is evidently some imperfection in the apparatus we may suppose that this consists in the tendency of all three fibrils, which normally correspond to red, green, and violet, to receive stimulation from any colour rays.

It is necessary also that a correct theory should account for contrast phenomena. These may be described as follows: If a grey disc be placed on a red background it will assume a greenish hue; if on a green background, a reddish hue; if blue, a yellow hue; and so on, the disc always assuming a tinge of the colour which is complementary to that of the background.

Helmholtz considered that these results were due to an effect of judgment. Hering considered them due to changes in the retina, and he extended his theory accordingly to account for such cases. He supposed

that if destruction, or katabolism, of any of the visual substances occurred in any part of the retina, the anabolism took place in that substance in an adjoining area. Long discussions have been waged amongst scientific men as to whether the phenomena are due to errors of judgment or to such changes in the retina as indicated by Hering. A possible answer is, that they may not be due to either of these causes.[1]

But we may now consider an experiment which is taken to decide that the phenomena are due to "retinal events," or that they are "peripheral" and not cerebral in their causation.[2]



A box is divided into long equal compartments by a vertical partition running the length of the box. At one end are two apertures, one in one compartment corresponding to the right eye, and the other in the other compartment corresponding to the left eye; so that each eye can look only into its corresponding

[1] In addition to the authorities already cited, an American writer, Ogden Rood, has produced a work on Colour-blindness. Cf. also W. de W. Abney, "Colour Blindness and the Trichromatic Theory of Vision" (*Proc. Roy. Soc.* 1910), and the Report of the Royal Society's Committee (Lord Rayleigh and others) on Colour Vision.

[2] See Starling's "Elements of Human Physiology," p. 570.

compartment. The other end of the compartment for the right eye is closed by a red glass plate; and the end of the compartment for the left eye by a blue glass plate. In each compartment midway between the coloured plate and the aperture for the eye is fixed a small grey cross on a sheet of transparent glass.

The eyes look, each through its corresponding aperture, at a point on the line where the red glass plate and the blue glass plate join. A fusion of the colours red and blue takes place, not perfectly but sufficient for the purposes of the experiment, the fusion tint being purple. The two crosses are found to be quite distinct, that seen by the eye which looks in the red glass compartment being green, and that seen by the eye which looks in the blue glass compartment being yellow.

If the phenomena by contrast were due simply to errors of judgment it would be inferred that both crosses would seem to be of the same colour, viz. that which is complementary to purple.

But to assume that the phenomena are "peripheral in their causation" is to fall into the error of Repercussive Association (see pp. 358, 359, and 505).

We should have to examine whether these two theories are the only possible theories. We find that the variety of shades of colour formed by the combination of the primary colours is very great. We find also that in correspondence with other parts of the nervous system the variety of movements formed by the combination of other movements is very great, and we have determined that the combinations and co-ordinations of these movements are a function of the brain. The development of the brain has proceeded in correspondence with the necessity for such co-ordinations.

If now we examine the retina microscopically we find that it is formed of certain parts the form of which is repeated in adjoining small areas. The extent of the retina affected has influence in determining directions, but apart from this function minute areas are self-sufficient with regard to receiving impressions of colour [1] (see pp. 53 and 512).

These parts show a structure which though complex has not that aspect of intricate relation of parts which we find in the brain, and which we would expect to find in an organ which was the physical correlative of the combinations of sensations.

It is therefore a generalisation, within the range of accuracy of most of those admitted in Natural Science, to consider that the function of the retina is to transmit the impulses, in their simplest expression, from which the various combinations are formed.

The combination of impulses in the brain is not a matter of judgment, though judgment is a factor. We might speak of judgment in a case where we observe the breadth of a box in comparison with its length. If the length be increased the breadth seems less. It seems possible that some analogous process might lead us to misjudge the tint of a disc when we had looked for some time on a background of pronounced colour.

But the fusion of colours, such as we know it familiarly, is automatic, so much so that we may be quite unable by force of vision to resolve the tint into the colours which form it. For different combinations there must be different processes in the brain, that is to say, the areas disturbed by the stimuli differ.

In the experiment we have considered we find a purple background as the result of the combination of red and blue. Now the combination of red and

[1] Hering, Holmgren, and others have devised experiments to prove this.

grey, and of blue and grey, are referred to different areas of the brain. Usually the processes are not masked by those due to the combination of red and blue. When they are freely formed, cerebral processes in association are set up. And even when the process is masked these associations still become manifested when attention is fixed on the grey crosses in turn, one with its red background, the other with its blue. We really see these in rapid succession. We shall be helped in the understanding of this by considering the chapter on the Unit, and by taking account of the effect of small repeated stimuli. In short we have here the ordinary process, slightly disturbed. But the elaborate apparatus, though producing only slight confusion of the natural process, has served to confuse our interpretation.

Thus, though we cannot use the term "judgment" in the sense of conscious comparison, yet we can, quite consistently with the experiment, believe that the phenomena have their explanations in cerebral processes (see p. 310).

Other experiments have been designed to prove that the errors of appreciations of colours in the contrast phenomena are due solely to effects in the retina, but since these experiments all depend on showing in a homogeneous background the different effects of various influences of contrast, they may all have the explanation already given of the combinations effected in the brain.

In these matters one observation is particularly worth noting, and that is the facility with which we classify these sensations under the generalisation of colours.

We may also classify smells, or touches, but we do not think of a smell as a colour, although there

are certain underlying associations, arising possibly from the very mode of our evolution. It is true also that we can form a classification to include colours and touches; but that depends on the fact that the effort of attention is the basis of the Unit. The relation of one colour to another is very much closer, and consequently the something common to all colours, by reason of which we form the generalisation, is closer. The various colours are due to differences added to the general base.

We find by experiment that very dim light, or light falling in a restricted part of the retina, gives no sensation except of illumination. In the peripheral parts of the retina there is no sensation of colour in any illumination (see p. 53).

We should therefore expect to find that stimulation of part of the retinal apparatus corresponded only to the basis of all the colours, and that the stimulation of some additional part of the entire apparatus was necessary for colour sensation.[1]

It may be that the functions of the rods and cones have some correspondence to this differentiation (see p. 69). In the periphery of the retina only rods are found, while the cones are concentrated at the centre of the retina and especially in the *fovea centralis*, the stimulation of which corresponds to the clearest appreciation of colours.

The special apparatus for colours transmits the impulses which are necessary for all the combinations in the brain, and such impulses may be comprised in the system imagined by Young and Helmholtz, or by

[1] This at least corresponds with the actual history of the evolution of sight. Cf. note p. 53. In this regard should be noted the fact, pointed out by Cohn in 1879, that a red spot 1 mm. square becomes visible at 14 metres, whereas a violet spot of equal area does not become distinguishable as violet at a distance greater than 2 metres.

some other different system. The end organ, for example, might be supposed to be a system capable of displacement by certain vibrations of light, but with a tendency to swing back to equilibrium, and in swinging back to overpass the mark. Different situations of the parts of the system might correspond to the vibrations which form the elements of all possible combinations.

We have, however, now reached the point in this question where there seems nothing to gain by further elaboration of hypotheses, except in as far as we may from time to time gain by microscopical research a more precise knowledge of the structure of the retina.

§ IV. Veritable Mode of Progression of Reason

It should be particularly noted that in analysing the process of Reason to its elements we are apt to regard the result of that analysis in too formal a manner, and to miss that essentially active, vivified mode of Reason which is most conspicuous in the highest examples.

It will be found that after reading exclusively in the higher mathematics, in some cases with meticulous care, in others only in the broad lines, the mind returns to branches left behind with much greater ease of handling than if it had laboured constantly in these. It is not merely that there has been acquired a habit of generalisation, a manner of looking at broad paths and ways and means, without being perplexed by detail; but there has been added a certain moral factor of confidence and of determination which is not without distinct value. These considerations will be found of importance in education, for nothing is more certain than that advance is not best obtained by simply plodding along paths which lie in the "logical order" of development of a subject.

Curious analogies will be found here between the process of mental development and that of physical development. For instance, in the formation of an organism the process is not that of a complete consecutive building as in the model of building a house regularly from its foundations, but the development often appears in patches. So with the mind, it will generally be found that in studying a subject there is not only the reasonable desire to obtain a view of the whole as quickly as possible, but there is also a tendency to glance at parts out of their "order." This does not prevent details being afterwards laid in even scrupulously, and the method is really scientific. It often happens that the brains of students are overwhelmed at the beginning of a subject by a mass of detail, and they never reach a higher level at all, nor acquire the sense of the developing of the subject.

But it is in research, in discovery, in the striking out of new lines of original thought, that we find the most remarkable divergences from the formal manner of conducting the mind. When we direct the eye towards a landscape certain sensations result. We recognise that the landscape is external to us, though the image may seem internal; our judgment is the result of a concordance of various factors which will be discussed in the chapter on Externality.

Similarly with all ideas. Thinking, in as far as operating on an instrument is concerned, is but the adjustment of that immensely complex meshwork of the brain formed of its nerve-strands and ganglia. We do not create the thoughts; we simply spread a web to the invisible universe and thought results. The process could be traced up from the simplest sensation following on nerve stimulus to the highest reaches of recondite thought. The brain is the instrument in a

sense analogous to that in which the eye is the instrument. This is all consistent with the theory that might be worked out in quite other directions that discovery, as in science, follows when the brain has been so occupied with a subject that all the nerve filaments have repeatedly vibrated in accordance with the arrangement of things in the phenomena investigated, and that these vibrations, by virtue of repeated tentatives, have experienced so many combinations that they are fitted to respond to the hidden harmony sought. For all law in external phenomena means ultimately the establishment of a simple scheme of harmony amidst confusing things. Hence the thinker knows he is on the eve of a discovery by reason of the approaches to and the glimpses of that ideal harmony, already felt in former trials.

These remarks might be illustrated by the examples of many great discoveries from the day of Aristotle to Pasteur. Aristotle, in studying a subject, we are told, used to gather all the information he could, then meditate upon it in a manner of absorption until some moment of genius gave him the clue.[1] In Pasteur's case the association is noted between his methods of patience, search, meticulous examination, and the gradual sense of illumination that showed visibly to his familiars that he was on the eve of a discovery.

It should be noted also that every brain searches, compares, devises, reflects, discovers, according to its development.[2] It has a natural manner of working

[1] Claude Bernard said: "You feel a slight shock of electricity which strikes your head and at the same time seizes the heart. That is the moment of genius. . . . Then all at once comes a flash of light. The new idea appears with the rapidity of lightning as a sort of sudden revelation."

[2] The physiological fact of the acquisition of medullary sheaths by nerve-fibres is related to the psychological process of Association; but the correspondences here indicated have a much wider scope.

when conditions are fair. Accordingly the aim of education, on the mental side, should look mainly to the development of the brain itself.[1]

After long toil, often with fatigue, as for example the toils of analysing complex and involved presentations, there may appear a mood of the mind when, without forcing the thoughts, but rather as if the thoughts took possession of the mind, a great array of facts and principles appear in a clear perspective; and analogously to physical vision, the mind sees relations, coincidences, deductions, vainly sought before.

The prelude to such a condition of mind cannot by what we know hitherto be determined. It may arise in a state of fatigue and disinclination to routine efforts, or it may arise, as in the case of illumination cited in his own experience by M. Poincaré, in the midst of indifferent occupations, or when the mind is excited by physical pain, as when Pascal on a night of torture by neuralgia worked out the theory of the cycloid.

The form of presentation, here likened to a perspective, may differ for different minds, but the notion of perspective is not necessarily artificial; for in our ordinary view of perspective we shall find that the ideas of extension are built up by accretions of sensations, and their relations, which taken separately have ill-defined presentations as being things posited and localised. The appearance of extension depends to some extent on the Feeling of Effort, on the impressions, freshness of presentation, and on their sequences. Amid many other things I have referred to these only as they are also to be found in such abstract presentations as that of a series of facts and principles.

[1] Flechsig's remark may be here noted, that genius arises from the structure of the brain.

Here we touch on one aspect of the mysterious domain of the psychology of research. Meanwhile, it may be asked is there not something extraordinarily fascinating, and curious to the degree of marvel, in the feeling of concordance and harmony in the discovery of true relations; as if indeed one might suppose that concordance and harmony resided objectively in the natural world, and that we had discovered our minds in a mood appropriate to its recognition.

PART II

CHAPTER I

ASSOCIATION

Association has been abundantly discussed in the course of the development of Psychology, from the time of Hartley onwards. There is no need now to travel familiar ground, especially as Association has, in the preceding exposition, been not only incidentally dealt with, but referred to its proper relations among the Fundamental Processes of the mind.

There are, however, other positions involving Association which should be discussed, and these positions may be referred to as enlarging the scope of Association.

We have observed that Association is found not only between Presentations in immediate sequence, and between ideas that have arisen in immediate sequence, but also between ideas related in any way to each other and to the objects of the external world.

But there is found also Association between ideas and emotions, and between different kinds of emotions; and between any of these and the greatest complexes that can be formed by combinations of all mental processes and feelings.

It would be well here to refer to the graphic representation provided by the structure of the nervous system itself (see pp. 95, 236). We find that

correlated to the Association of idea to idea we have stimulations producing disturbances along a nerve track from one brain cell to another.

In active mental life there is a simultaneous stress along many related paths. In cases of mental excitement there are explosions in brain cells and perturbations along paths that have no special relation to the immediate stimulation of external nature.

In cases of profound emotion there is a wide area of disturbance throughout the nervous system.

We have already seen the influence of the emotional factor on Reason (see pp. 349, 357 *et seq.*, 362). It is not only a factor in producing belief, but it influences the manner of expression of that belief.

Shakespeare, who was a keen observer of human passions and also of their proper representation, has a fine passage where Cleopatra receives tidings of Antony (cf. Act II. scene v.):

> MESSENGER: Madame, he's married to Octavia.
> CLEOPATRA: The most infectious pestilence upon thee!
> [*Strikes him down, etc.*]

Here we find the Association of an emotion of anger with the source of the news that produced the anger. Observations of the kind have become proverbial, as in the advice not to be the bearer of bad tidings, and the notion, more valid than a mere superstition, that ill-luck attends the bearer.

Another passage of Shakespeare is more subtle, but not less dramatic. Othello, shocked by the tragedy of his own acts, works himself up to the point of suicide:

> And say, besides, that in Aleppo once,
> Where a malignant and a turban'd Turk
> Beat a Venetian, and traduced the State,
> I took by the throat the circumcised dog
> And smote him—thus. [*Stabs himself.*]
> (Act V. scene ii.)

Here we have a reminiscence exciting a feeling of rage and desire for destruction, and this becomes powerful enough in Othello's despairing condition even to be turned against himself. The Association here is not merely between a dominating emotional state and a certain notion, but also between that emotional state and the image of the act to which it led.

We generally find in cases of deep emotional disturbance abundance of gesticulation. This would be explained on the physical basis by saying that the disturbance along sensory nerve tracts in the brain produced disturbances in the areas of the motor nerve tracts corresponding.

Among people such as the French, where gesticulation even without great excitement is usual, habit has facilitated the passage of the disturbances from the sensory nerve tracts to the motor nerve tracts to such a degree that it becomes difficult to express an idea without the accompanying of motor displays. Frenchmen often gesticulate when holding a conversation through a telephone.

In persons of unsound mind, also, nerve instability, shown in incoherent ideas, finds a further expression in want of control of physical acts. A raving lunatic desires to do something, perhaps to kill.

The influence of Association is found in determining in a wider scope, and over a greater length of time, the expression of a man's thoughts. Compare, for example, the works of Rabelais and Pascal. Both aimed at reformations in spiritual matters, but their temperament and education were different.

With regard to Rabelais, it is said that he was a profound moralist who cloaked his ideas in an extravagant manner in order that the essentials of his teaching would find easier acceptance. His gainsayers assert that he desired only to amuse, or to outrage decency, by

the frivolity and ribaldry of his language and the licence of his descriptions. Both these positions seem over-strained. The works of Rabelais have an aspect of being a satire on the abuses of his time, but his mind was coarse, and filled with licentious images, and these he makes use of in the portrayal of his views.

The mind of Pascal was delicate and refined. His educational development was profound in certain directions. Ill-health, together with an ascetic régime, provoked the hysterical tendency always underlying in his nature. Consequently, with the expression of a fine, luminous intellect, we have in his writings the most poignant cries of distress in literature, and the warping towards madness.

Now, if the style of Rabelais be purposely chosen to form a proper vehicle for preaching reforms, is it possible for us to imagine Pascal adopting such a manner of expression? We see in both cases the Association of temperament with intellectual acquirement.

In the case of Shelley we have a constitution not unlike that of Pascal, except that the tendency both of his temperament and his education was to find expression rather in poetical flights than in ratiocinations such as delighted Pascal. Shelley's mind, no less than Pascal's, was steeped in Christian influences, although his professed principles seemed absolutely opposed, at least in dogma, to the Christian religion. We find these tendencies expressed in peculiar Association. Shelley's "Queen Mab" is ostensibly a revolt against religion, expressed even in terms which Christians consider blasphemous; but the essence of his whole discourse is that of appealing to the Christian spirit, while condemning those whose example is in disaccord with Christian teaching.

The influence of Association is found in cases where

a man with a strong bent towards one set of notions is also immersed in daily practice in another. Such was the origin of a book that had a large circulation some years ago: "Natural Law in the Spiritual World." Drummond, the author, was a devout Christian, and at the same time a lecturer in scientific subjects. Accordingly he desired to infuse the spirit of science, and even the examples drawn from his scientific work, into his religious views.

On the other side we find such cases as that of Huxley. For Huxley, being profoundly interested in ethical questions, and being at the same time a brilliant student of biology, makes use of biology as the medium of expression of his opinions in ethics (see pp. 501 *et seq.*). It must not be supposed that Huxley found in biology alone the cogent proofs of all the conclusions he reached. His opinions depended on numerous other factors, including other forms of his education, his early training, his temperament, and the more technical considerations of the field of ethics itself.

If, for example, a certain standard of conduct is found to prevail throughout the organic world, then its application to man may possibly be rejected on the simple observation that the new conditions introduced involve modifications of this standard. This is indeed the conclusion of Huxley himself in his later writings. Other biologists have refused to alter the continuity of their system. The decision depends partly on temperament, and on the other factors noted.

Darwin's work on the Origin of Species caused great commotion. But this was in part due to conditions accidental to the history of science, viz. that it was declared by the foremost authorities of the Christian Church to be inconsistent with the Bible. The writings of Huxley were frequently a direct attack upon the

validity of Christian doctrines. Hence, as so many of his arguments were ostensibly derived from his biological work, there arose a notion amongst advanced thinkers that biology was in a peculiar sense the spiritual science, that salvation lay only in that way (see p. 393).

Biology was the science that attracted the enthusiasts of serious culture. But the great majority of these were disappointed One does not find "The Data of Ethics" as the residuum of a chemical retort nor in the dissection of an earth-worm. The actual study of biology is a work of patience, and it is only after a vast stock of knowledge has been patiently accumulated that any reliable lights upon questions of ethics may be discerned. Even then, examples are abundant of men who are expert technicians in the realm of biology, but whose opinion on other matters has no particular value. It requires rather a deep contemplation of the principles and results of all related sciences to obtain, within the scope of these, some clear notion of the phenomena of the world; and the certainties met with in the way are rather those of the futility of weaker systems.

The influence of some great authority in impressing on a generation the importance of a science is itself an illustration of the widening of the scope of Association. From generation to generation we observe that there has been a succession of fashions in science, according as some great discoveries have laid bare a portion of Nature, and as no discovery of this kind is without a deep spiritual signification, it has happened that other sciences, before biology, have been considered especially as the spiritual sciences (see p. 393).

Mathematics had its great day in the time of Descartes and Pascal, and, later, reached its crowning glory with the discoveries of Newton.[1]

[1] Dr. McCormack, an American mathematician, tells us of the days when fair

But even nowadays we find from time to time curious expressions of mathematics as the transcendental science. One of the most remarkable of these is that of Prof. Keyser of Columbia University (see p. 502), who, being a mathematician and a theologian, endeavours to find in pure mathematics the assurances of the existence of the Deity. Here we have an instance of Association bridging over ideas that to most would have seemed extraordinarily remote.

Mathematics in its own field is one of the most objective sciences. There is not much ground for emotion in the fact that the angles at the base of an isosceles triangle are equal, yet even in pure mathematics we find scope for Association with temperament. Bernoulli said of an anonymous solution to a problem, which was really by Newton, that he knew the lion by his claws. In reading the exposition of Quaternions by Hamilton one is struck by the meticulous care of his manner. The ardent spirit of Abel is displayed in his attack of problems in bold generality, and in his trenchant display of deep principles. This impression of Abel's style has been even rendered graphic, when it was said of the "good old geometer" Legendre that he could not keep pace with the young giant.

An illuminating remark on this subject occurs in a lecture on Riemann by Prof. Klein of the University of Gottingen, in which he indicates how Riemann's profound conceptions had their origin in mathematical physics: "You see that even in the domain of mathematics individuality plays a great part."

In philosophic questions such as, for instance, the exposition of the regulation of the world from the stand-

dames discoursed of differential coefficients and the precession of the equinoxes, and when Euler's letters to the Princess Elizabeth had but one rival—those of Lord Chesterfield to his son.

point of ethics, we find at once a greater scope for temperament and a less control of results. Consequently we are not surprised to find on all ethical systems the imprint not only of the author's thoughts and experience but also of his temperament.

John Stuart Mill found this in his relations with Comte, for Mill with his liberty-loving character became shocked at length to discover that Comte, though a rebel to orthodoxy, would impose on the minds of men a tyranny founded on the principle of organisation of the systems he had renounced.

Herbert Spencer's theory of Evolution has no authority over certain parts of his writings, as, for instance, his theory of the origin of baldness. It has not much more even in his views of Education or the relation of Man tc the State. And although "The Data of Ethics" is the crowning of his work, there is no complete cogency oi argument between the positions of the doctrine of Evolution and those of "The Data of Ethics." We find here the influence of the author's surroundings and of his temperament. It represents the best side of the bourgeois ideal: peace, the development of trade, mutual help, justice.

But Kant gives to ethical duty a sterner and more uncomprising character, representing an interpretation more akin to the Stoic philosophy, while Spencer's savours of Epicurus.

As these doctrines of conduct are inconsistent, it follows that they cannot both be right. Neither results from a study in objective style of all factors, with a rigorous demonstration from accepted first principles. Such a demonstration would be extremely difficult.

We have seen how the principle of Association affects the total display of a man's personality, and that amongst authors it colours even their expositions in objective realms.

The converse problem may therefore be posed: Given writings of an ostensibly objective character, is it possible to find revealed in them evidence of the author's personality?

This is certainly the case. Consider, for example, the dramas of Shakespeare. Here we have a great deal of material on which to work. Many of the characters moreover are imaginary, while those that are historical are liable to interpretation according to the dramatist's conception; and certainly Shakespeare has in some instances allowed himself the utmost latitude in this respect, as, for example, in the character of Achilles in "Troilus and Cressida."[1]

But besides the manner of dealing with the plays themselves Shakespeare had free choice in the selection of subjects.

A method of analysis therefore, in order to discover the influences of Association of the character, temperament, origin, and acquirements of the author, would in the first place set forth for consideration the actual choice of the subjects, in their chronological order if possible, and the reasons of that choice.

Useful suggestions may be obtained by the study of the choice of other poets. Milton did not select Paradise Lost as the theme of his epic until "after much choosing," and in the course of the poem he gives the reason why he departed from the usual style of epic. The impress of the poet's individuality so strongly marks the poem that it may be considered in the light of a spiritual biography illustrated by the great imagery of the epic.

If we consider, in this aspect of Association, the

[1] This, however, is one of the disputed plays. But compare the delineation of character of Antony and Cleopatra with that of Ferrero. With the Italian historian we seem to move in realities; Shakespeare gives us a gorgeous fairy tale.

dramas of Byron, of Shelley, or Sheridan, we find how intimately related to the personality in each case are "Manfred," "The Cenci," and "The School for Scandal" respectively. Even in an author of most objective style the choice of subject gives indication of his character.

Then we consider the treatment of the subject. Here we have innumerable possibilities in the general atmosphere of the play, the selection of the persons of the drama, their relative importance in the whole perspective. Even in a subject of objective interest there are a thousand manners in which temperament may be shown.

Then there is the consideration of favourite words or phrases. With men dominated by some fixed purpose there is always to be found some characteristic expression, such as the "Delenda est Carthago" of Cato, or the "Thorough" of Stafford, or "Le cléricalisme, voilà l'ennemi" of Gambetta.

But even where there is no dominating idea the temperament may be espied by the more frequent recurrence of certain words or phrases, and these should be looked for in passages where they do not arise inevitably out of the situation.

Another test would be that of the references to the dominating notions or purposes of others, or to the burning questions and fermenting ideas of the time in which the author had lived. In Shakespeare's time particularly the question of religion was vital. England's position in the world's politics also had been in jeopardy, and she had triumphed in brilliant style. In the realm of thought the genius of Galileo was enlightening the world; Gilbert was working in the approved methods of modern science; and Bacon "rang the bell that called the wits together."

All these subjects of deep human interest must have

thrown themselves with strong dynamic force into the attention of alert intellects of the time. Hence we obtain indications of character and intellect and temperament in the attitude towards these subjects, for in such matters even silence is significant.

Then we again obtain further indications in the dramas more or less ostensibly philosophic, such as "The Tempest," or in those where reference is made to questions of philosophy or religion, as in "Hamlet."

Then there is the consideration of the works taken as a whole, with the view of estimating intellectual energy according to the output extended over some years.

It would be out of place here to hazard opinions as to the results of such an analysis in the case of Shakespeare. The reference has been made to indicate in what way the principle of Association may be regarded. We have seen how in cases of known personalities it has influenced the expression of their thoughts; then it is reasonable to suppose that our line of criticism may be elaborated, having regard to this principle of Association; so that from the expression of thoughts we rise to an appreciation of the style of their author.

The Association of idea and emotion has been worked out by M. Godfernaux in "Le Sentiment et la Pensée," a book remarkable alike for the depth of the thought and for the character of the investigations. Godfernaux finds emotion or sentiment as the force which produces what is called Association of ideas. I will not enter into a criticism of these notions, partly because what is true in them will, I believe, be found here expressed, and partly because even this enlargement of the scope does not carry us far enough. We must embrace all that is contained in the aphorism: "The whole man thinks."

Thus it would be possible to elaborate a study of psychological politics, based ultimately on physiological politics. A famous statesman, in the decline of life but full of vigour and in enjoyment of a commanding position, desires to signalise his career by some new great exploit. Here, in addition to all the objective considerations arising out of the condition of the nation, would necessarily be present the suggestion that the question to be tackled must be important and difficult, yet not such as to escape the compass of the years still allotted to his activity. Factors of this kind tell in the history of the world. They are to these great annals what the one last bumper is to a convivial gathering.

A patriot who is also a musician will in time of stress produce a national song. The greatest example is Rouget de Lisle. A great poet, in disgrace, blind, undaunted, scornful, rebellious, will send forth a "Samson Agonistes." And the philosophers have interfused their philosophy, especially their ethical conclusions, less with the essence of eternal verities than with the emanations of personal temperament.

The study of Fechner's law is interesting in that respect (see p. 225). This law, which professes to indicate a numerical relation between objective stimulus and subjective impressions, is of general application; but a study of its origin reveals to us that it is compacted of the three dominant passions of Fechner's intellectual life—Psychology, Physics, and Mysticism. Many great physicists before Fechner had studied Psychology, and many great psychologists had studied problems of physics, but they had held these matters apart in their minds. Weber had indeed endeavoured to introduce into Psychology measurements as exact as possible, but compared with Fechner, the difference was as that of

looking at a sacred vestment with the judgment of a weaver or with the rapture of a believer. Fechner did not merely seek to measure phenomena, he desired to bridge the interval between two realms of speculation. Hence we discover in the end that he has performed that improbable feat, the application of the Differential Calculus to mental impressions, the testing of sensations by logarithms.

That Fechner should have been satisfied we can well imagine, but it is more difficult to understand how he could have persuaded independent thinkers to follow him. Certainly at the beginning many of the most eminent held aloof, but now Fechner's law has been established as amongst the precious mysteries of psychological faith.

But here also we obtain a clue. Whatever is wholly rational and explicable falls into the light of common day, and ceases to afford that which is to most of us a heritage of the ages, the thrill of wonder, of mingled resistance and attraction, of enjoyment and sacrifice, of strange imaginings, ecstasy, and devotion, in the presence of superior things veiled in mystery or secluded from impious touch. Fechner's law becomes the palladium of an institution, or the Caaba of a faith.

Moreover, there enters into play the Associations derived from professional pride. Examples of these abound in profusion. I will select one that was revealed to me unexpectedly. Some time ago I was reading an article in one of the medical journals on the thoroughly technical subject of the "Submucous Resection of the Nasal Septum." The whole matter was discussed in the style of a competent specialist, but the conclusion particularly interested me: "And now it can be no longer said that nasal practice has no major operation."

Here at length the veil was lifted from the soul of the rhinologist. He had been doing good work, he had won that esteem always accorded to virtuosity in practice, he had the rich fields of anatomy, of comparative anatomy, of histology, of bacteriology, of Experimental Psychology, to roam in; but we find the secret gnawing of envy, jealousy of the exploits of enterectomy of the general surgeon, or of the operation on the Gasserian ganglion of the neurologist. All this was contained in that gem of professional pride thus unconsciously exhibited.

The psychological world, although a world of purer reason, has not entirely escaped such influence. It is found in pedantic language, in oppressive formalism of style, in that appreciation both of authority and obscurity which has made Hegelism the banner alike of Prussian autocracy and of intellectual Socialism. It is found also in the creed of Fechner's law. For hitherto the Psychologist, and especially the metaphysician, has felt the eye of the physicist upon him, has felt even the unspoken reproach of barren studies in realms of unreality. Now he can reply with Fechner's law. That is a great instrument, for few can understand it, and it is worked with logarithms.[1]

Another aspect of Association in its wider operations is that of the atmosphere of our studies themselves; for it may shock some, contrary to the famous Horatian precept, to smile in the search for truth, or to laugh when some absurdity crops up.[2] This arises partly from the old traditions of religious strife, when truth

[1] It may be well to refer again to the criticism of Fechner's Law, p. 225.

[2] Quanquam ridentem dicere verum
Quid vetat?—HORACE.

There is also a passage of Phaedrus, usually rendered rather too stiffly, bearing on this. A free translation is: Let the mind play at times that it may the stronger return to work.

itself was clad in harsh and forbidding aspects. It arises also from the belief that the man of science must necessarily be of a severe cast of mind. Certainly a vast amount of technical work lies in his way, and the influence of such toil is to conduce to seriousness; but the history of the world shows that the highest genius in such matters may consort with a temperament not always severe—Plato, Aristotle, Descartes, Fermat, d'Alembert, Ampère, Davy, Rumford, Huxley, and Clifford attest it.

We have already seen that Reason itself does not proceed by a concatenation merely formal of ascertained propositions. It will be evident that if what is advanced in this chapter be considered in all its import of life and interest, curiosity and attraction, a new notion will arise as to the conduct of the mind in research and in the striking out of a life's work.

When we contemplate such a career as that of Darwin, we discover him first a sportsman, then a naturalist, and gradually we observe the spirit of mere sport becoming less and less and the interest of deeper questions steadily growing. Then we find a great and capable mind addressing itself to profound problems that lay within its scope, and of which the research was fraught with great importance to various spheres of human activity.

Here then we recognise as not loosely associated with the manner of thought, but interfused and providing for it the necessary motive force, the great moral qualities of patience, sincerity, judgment of values, and courage; and we see these in active play alike in dealing with questions that arise from time to time in course of studies and in the planning and carrying to determinate issues the bold scheme of the life-work itself.

SUMMARY OF ASSOCIATION

Association is a Fundamental Process. This refers to the simplest form of Association, as between Presentation and Presentation, and between Presentation and idea, or between idea and idea. But we may also find Association in cases where the objects are more complex, and where the understanding of the nature of an object involves a complexity of Fundamental Processes. Even in such cases the final act of Association is that of a Fundamental Process operating on Symbols.

Hence in using the word, now in a larger scope, we find that the function of the mind is such that Associations are formed between Presentations in succession; between Presentations and ideas; between ideas and ideas; and hence by means of symbolisation between extensive systems of thought; between ideas and feelings; between ideas and complexes of ideas and emotions; between any of these incidents of the mental life.

Associations are determined by circumstances of the greatest complexity and involving many factors of the individual existence which do not come into consciousness. Thus Associations are determined in their course by temperament, education, and intention of life.

In the physical basis corresponding the course of nervous excitation may be determined not only by the mutual influence of contiguous cells, but by connections established with remoter areas; and, from physical causes in the body, or as the result of stimulation from without, or from causes dependent on ideation or emotional disturbances, the course of nervous activity dominant at a given moment may be broken up, and new series of nervous excitations established.

Hence the notion of the mind moving along a "chain of Associations" is wrong if this refer to a pre-established chain; and if not, then the phrase loses meaning further than that ideas arise in sequence.

In reference to the application of the study of Association we find that since the resultant at each moment is determined by the combination of the subjective and objective factors, we have in the expression of that resultant a factor in determining the character of the subject.

In the study, say, of Shakespeare by this aid we might inquire: What is the general temperament and the atmosphere of inspiration of the works; or in a long series, if they can be determined chronologically, what are the sequences and the changing spirit of the atmosphere of these?

What are the evidences of education, or of special training, in the works?

In how far does the technical skill shown in reference to versification, or stage-craft, compare with that of contemporaries?

What is the character of the knowledge displayed? Is it strong in the science of the time, or in history as then known, or in the observation of character taken in the life?

In all this, what conception arises of a development of mind?

How is the bent of mind shown in oft-recurring words, in ideas brought into associations not usual nor inevitable, in sportive moods, or off-hand not seasonable expressions?

What is the attitude towards great striking facts of the time, either of politics or of religion?

Is the cast of the mind analytical in a scientific sense?

Where is admiration displayed? Where fondness? Where tenderness? What is the character of passages that break forth most naturally, or spontaneously, with enthusiasm, with warmth of language, with wealth of association, with an air of freedom and familiarity, or with imagery inspired, or surprise of happy touches?

From all this might be built up, in works as extensive as Shakespeare's, especially with the help of direct biographical references, a well-defined and various character.

The Association of idea and emotion extends to the widest scope, so that we may say: The whole man thinks.

Every Philosopher has interfused his temperament into his philosophy, in whatever objective terms this be expressed.

The study of Fechner's law indicates the influence not only of his studies of physics and psychology, but also of his bent towards mysticism.

Associations less definite, but persistent, affect the atmosphere in which either professional work or the discipline of a science is regarded.

Historical causes account in part for the austerity of the atmosphere of science.

Moral qualities are no less necessary than intellectual qualities for the carrying out of a great work of science.

CHAPTER II

EXTERNALITY

Scottish philosophers, Reid and others, formed the "Common Sense" school. They declared that the external world existed because they saw that it existed; their common sense told them that it existed.

Berkeley declared that all this was explicable on the basis of Idealism; a complex of ideas gave us the impression of material things, but ideas only existed.

We shall here find, not that these two theories are reconcilable, but that, if what is valid in the analysis of both be extended by still more persistent analysis, a basis will be discovered where all apparent inconsistencies are resolved.

But in the first place, let us strip "common sense" of some of its pretentiousness.

Bishop Butler, it will be remembered, when he endeavoured to get a universal standard of right and wrong, set up as final judge the "plain honest man." And Tolstoi has conferred on the same type pontifical qualities of infallibility in art. One may suspect that the plain honest man is in these cases rather a stalking-horse for a more powerful personality behind. But those of us who familiarly know the average man are by no means so impressed by the perspicacity of his intellectual vision or the lucidity of his expression.

By the fact that he is the average man, too many

streams of low origin have united to form his character. So far from the plain honest man possessing unerring judgment, or overwhelming majorities wielding any valid authority in intellectual matters, we have found that at momentous turning points of the world's civilisation the judgment of one man has deserved to outweigh that of all the rest of humanity; and that one has not been of the type of Reid's Common Sense or Butler's plain honest man. Such a man was Empedocles when he foreshadowed the theory of Natural Selection; such a man was Archimedes when he saw clearly the principles of specific gravity; such a man was Roger Bacon exploring the mysteries of chemistry; such a man was Copernicus beholding the verities of the solar system.

The man of common sense scoffed at the notion of the earth revolving around the sun, for he said he saw that the sun revolved round the earth, and his common sense sufficed. The plain honest man ridiculed Darwin during a generation.

Let us now examine Berkeley's position. We may begin with simple sensations. If we find that Externality be required to account for such phenomena, it will be necessary to the explanation of complex Associations of these.

Berkeley must, of course, postulate mind, for if there were no mind there would be no sensation, and if there be no Externality for a developed mind there will be no Externality for a rudimentary mind.

We arrive, then, at the consideration of a rudimentary mind.

There must also be but one mind, for a mind cannot think without sensations; and if there be another mind, that must have sensations also. These sensations must be different, for how can two minds have one and the same sensation?

If two minds existed, Externality would be implied; for what would be the meaning of saying that the actual sensation was not external to another whose experiences were different sensations?

If we consider a single rudimentary mind, we find that its sensations have characteristics of kind, intensity, duration. But there is nothing in this by which the mind can anticipate its sensations, or modify or check them. Even if we consider a developed mind, we find that there are sensations which the mind cannot anticipate. On these lines, then, one would be reduced to the contemplation of a solitary mind, but without control of the phenomena produced within itself, or without any prescience of its own movements.

Such a position is not unthinkable, but at least one could hardly persuade another mind that it had no sensation, and no existence beyond one's self. Descartes gave out the doctrine that animals were mere automata, and that a cry of pain, for example, was simply the creaking of the machine under certain circumstances. Berkeley does not appear to have believed anything of the kind concerning human beings, for he occupied himself with various schemes, not very practical as it turned out but at least practicable, for their benefit.

It would be competent, however, for a Berkeleyan to believe that his was the only mind in the world. But we will see that even on that basis he might arrive at a view of Externality which the common-sense representative, except for the exclusion of his particular mind, might be led to adopt.

We might suppose a mind not endowed with sensations through either sight or hearing, and yet attaining an extraordinarily developed notion of the world. Miss Helen Keller is a case in point. She has her other senses intact, and greatly refined in exercise.

We can scarcely expect to find a person furnished with only the sense of touch; but we may imagine ourselves as, upon occasion, refraining from the exercise of any of the other "five senses."

A sensation is now introduced. What we have learnt to speak of as intensity and duration could not be appreciated as such, but still they would afford their definite effect, in so much as that whatever the influence in the mind it would be different if these were different. If after the cessation of this sensation another were to follow of a different degree of intensity, the difference would be appreciated.

In this way we might have a world consisting only of sensations of touch, and varying in intensities.

Let us now add to the capabilities of our mind the muscular sense.[1] This brings to light clearly the Feeling of Effort, which accompanies all sensation.

Now after the recurrence of the muscular sense, with certain duration, there may follow other sensations of touch. Imagine, in order that the exposition may be understood, the person stretching out an arm and touching something.

The muscular sense will be found, on close attention to be not simple, but to have certain characteristics corresponding to the circular movement of the arm. Imagine these characteristics changed; effort with regard to the muscular sense being increased; the sensation of touch increasing in intensity. This would correspond to the familiar experience of the hand meeting with a firm object.

Here is a combination established in regard to what we will afterwards consider, in its complexity, as the external world.

[1] Herein is assumed nothing as to the veritable nature of this sense, or the origin of its manifestations.

It must be noted that as far as we have gone we know of it only through changes of sensation of a definite character arising unexpectedly and therefore without control from ourselves; and that the changes of sensation are mainly of the nature of interruption of some of the factors of the muscular sense, intensification of others (as in those muscles which aid in forcing against the resistance) and also intensification of the sense of touch, and of the accompanying Feeling of Effort or both.

We find also that except for this intensification the complex of experiences does not change, and we find also that if a certain intensification be retained the whole process now persists in constancy. Looked at from outside, this means an even pushing against a firm object. The negative (cf. pp. 35, 127) of this series would be followed by the sense of touch disappearing while the muscular sense derived from the negative movement continued. Let the whole operation be repeated till it is familiar.

We will introduce symbolisation in order to facilitate explanation, but we remark that this implies no new complexity; for though the symbolisation be not by words, yet the repetition of an experience invariably introduces symbolisation, even if it be by means of the initial steps of the experience symbolising the whole. We have already discussed this (cf. pp. 29 *et seq.*, 108, 113).

We will therefore adopt, in order to refer to the complex of our sensations, the symbol "External world." We must note particularly that it is not intended hereby to beg the question. We adopt the term for convenience of exposition, but we do not imply in its use anything further than we shall meet with as we proceed to develop our experiences. It will then

remain to be seen whether the whole meaning that thus arises from our symbol, "External world," contains anything less than, by appropriate analysis, the Common Sense philosopher would find in the term.

The symbol "External world," by experiences of the sort described, soon becomes diverse. To the complex we have already described therefore we apply the symbol "table," or more precisely, top of table.

Consider now what happens when we come to the edge of the table. This would be presented thus: The first experience is renewed. The sensation of touch continues without intensification. Certain appreciated changes are given to the muscular sense; then suddenly the sensation of touch disappears, but the muscular sense continues as before. On forming its negative the sensation of touch reappears.

The sensation of touch continues when the muscular sense undergoes another appreciated change. This would be known to us ordinarily as feeling over the side of the table.

A development of this method will convince us that, given the sense of touch and the muscular sense and the Feeling of Effort, we form a conception of the External world with regard not only to touch but to shape, and size, and also to resistance as far as this is expressed by the complex of the sensations of touch and the muscular sense.

So far we know nothing more than our combinations of sensations, and their Associations in memory. These faculties we must always imply in mind. But we cannot say that nothing more can be known than these ideas which we have indicated. The table, for example, was met with unexpectedly, and in the External world we may at any time meet with some object unexpectedly, that is to say, in a manner to interrupt,

independently of our control or desire, any sequence of ideas in association, or any combination we may form.

We may now, for the purpose of exposition, abandon the tedious reference to first principles, and employ ordinary terms, but without making assumptions unjustified by our method.

Let us suppose that the mind considered had not been endowed with the sensations of touch but with those of sight. With this sense alone there does not seem to be any suggestion of distance nor even of space as we ordinarily understand space. An appeal must here be made to introspection, but to aid introspection the following experiment may be tried: First divest the mind as far as possible of ideas already formed. Then keeping the whole body still for a long time and without moving the eye or even winking gaze steadily on a quiet scene. It will be found that the impressions of distance, of resistance, and of solidity become lost. The sense of colour persists, that of space also remains, if this be interpreted to mean the impression of shape and of place, but neither of these terms must be considered as possessing all the ideas usually associated with them, but rather a peculiar distinctive character as forming part of an assemblage of objects disposed in a certain way.

However, as we have already seen, the eye is adjusted for vision in various ways by different muscles; corresponding to the movements of some of these muscles there are definite sensations.

The action of the muscles of the iris, causing contraction or dilation of the pupil when the illumination is increased or decreased, is automatic, and probably there is no appeal in consciousness corresponding to this muscular action alone. In the case of accommodation for distance the action of the ciliary muscles is

automatic, but if the act be energetic other muscles are really involved. Thus in general there is associated with the action of accommodation a certain condition of the muscles directing the eyeball.

It must be noted that the direction is never maintained by an absolutely rigid system, but by constant balancing with appropriate innervation of the muscles and with the endeavour to reduce to a minimum the errors of direction oscillating round the true direction.

When change of accommodation for distance takes place, the directing muscles move accordingly, so that associations are formed by this habit; and when, in an experimental case, we desire no change of direction, an effort of adjustment of direction, correcting the usual action, is necessary.

The combinations in various ways, both of concurrence and succession, of the pure visual sensations first considered and those of locomotion, accommodation, and changes of illumination, gradually show the connection between the variations of the visual sense and locomotion, and so we add to our impressions and ideas the appreciations of what we afterwards know as solidity, and space.

It is necessary to use the phrase, "afterwards know," for there is nothing so far to tell us what effects of touch correspond to certain visual effects. We can only know this by experience.

We are fortunate enough in having been able to test this by actual experiments. The most famous is the case of the patient operated on by Cheselden for cataract.

Molyneux had asked Locke whether a blind man who knew a sphere and a cube by touch would be able to distinguish them correctly on receiving sight. Another philosopher expressed surprise that they should agree that he could not. It was ascertained

that Cheselden's patient was unable to decide by sight alone which was the sphere and which the cube previously known by touch. He thought also that distant trees were resting on his eyes.

Although the result supported his opinion Locke perhaps went too far in pronouncing definitely, for who could tell before actual experiment what connection, having even a physiological base, might be discovered between the senses (cf. pp. 57 and 511)? But the wrongfulness of dogmatising on the other side was clearly shown.[1]

Suppose now that in our External world we bring together the experiences derived from sight, from muscular action, and from touch. Then it would be observed that the series of touches and locomotions which gave us the impressions of shape and size were connected in a definite way with the series of visual sensations, and with each experience the corresponding ideas would be more and more strongly bound in Association.

We might now deal with the relations of the other senses in turn to the External world. We would investigate the character of this world in each. Afterwards we would show their connection with the others.

A distinct help towards a reconciliation of the Idealist with the Common Sense philosopher is found in the study of such an act as picking up a stone. The Idealist looks upon the stone as made up of ideas, but he sees this complex of ideas in certain relations to other complexes of ideas. If the stone be taken up and removed, then one set of complexes are held

[1] A case has recently been related in *Harper's Magazine* by Dr. Edward Ayers, where the patient recognised apples as round, and named colours at once correctly. A consideration of what has been previously said of Association between the senses would serve to explain this result.

all together, while they change their relations to other sets.

It is found convenient therefore to indicate such a constant complex by a symbol, stone; and we find that the complex contains visual ideas, ideas of touch, ideas of resistance depending on the muscular sense, and more abstruse impressions, resolvable, however, into ideas which we speak of as weight.

If now we take an example of acts expressed in ordinary language, we may show how they could also be expressed in the symbols of ideas we have found in our analysis.

Thus: I went into the garden and plucked a rose and smelt it. This would be expressed by relating the character and duration of the locomotive sensations in their successive phases, accompanied at each point by the other sensations corresponding to the term "walking in the garden"; then would follow the account of the more particular touch sensations with the more restricted locomotion of the arm and the fingers in grasping the rose, and the peculiar changes in the character of the combinations of these accompanied by the characteristic sight sensations in the plucking; then the whole series would be succeeded by the smell sensations.

The difference between this elaboration of the successions and combinations of ideas and the ordinary form in which we tell of the experience is simply due to the development of symbolisation, applied to those combinations of ideas that have an intimate and persistent Association as well as frequent recurrence.

It must be noted that the sense of distance, as for instance of the rose tree, is produced by the visual sensations arising from the tree, by the muscular sensations, and by the sensations of changes of accom-

modation and illumination, in looking at the tree; then by the impression of the continuous series of objects from the tree to the place where the person is standing; then by the muscular sensations of locomotion with the series of constantly changing Efforts involved in so taking this series in order, that is to say, in getting close to the tree, that the sensation of touch may be added to the others.

Is this all, however, that is contained in the meaning of the external world? We have already observed, in the case of the table, the factor of the unexpected.

Let us consider an object: Iron. The Idealist would say that this can be resolved into a bundle of associated ideas. This is true with reference to those attributes of which we have had experience, even of such remote relations as specific gravity. But this is not all that is contained in Iron. The iron becomes electric and develops new and remarkable properties, which no amount of the most skilful analysis or introspection employed in the "bundle" previously symbolised as Iron could have indicated.

We could not predict these properties, nor, after their appearance, form any expectation as to their development or persistence. Nor could we by appealing to our previous knowledge of iron and sulphur as bundles of ideas predict the wonderful effects of their combination, and the entirely new series of the bundle so formed.

In the next case we may consider another individual, and particularly, in that individual, what familiarly we speak of as mind. It will be remembered that hitherto in working out the problem from the Idealist position we have excluded other minds, but now though we use the word "mind" we may consider it only in its phenomena. Thus Descartes, while believing that

animals were automatic, might talk of them in ordinary terms.

But in dealing with mind we have a still more inefficient grasp of the "bundle" than in the previous cases, and the unexpected becomes more marked.

The indications of other minds traverse a far more extensive range than those of inanimate objects, and extend themselves beyond the scope of our calculations, and yet from point to point reappear within the sphere of our knowledge and our anticipations.

In all this the character which is most strongly objective is the unexpected, the complex of ideas that arise beyond the scope of anything we have known or could elaborate by any kind of combination of ideas which had existed in our minds, or which our minds could anticipate or in any way control.

Everything else may be expressed in ideas and their relations—that is to say, subjective states. This property of the unexpected we must except and make provision for by the "something, I know not what," of Locke. This phrase brought censure on Locke from other eminent philosophers, but it seems admirably to indicate the carefulness of his method. His analysis is not always final, but within its scope is seldom wrong, while for delicate introspection and accurate record of mental experiences he has not often been equalled.

The "something, I know not what," is the something independent of previous mind, entirely dependent on experience, and capable in its independence of being developed indefinitely in other unexpected forms.

But when once we admit any objectivity we must admit it with respect to mind. When we admit another's mind the whole External world opens up precisely as the Common Sense school, if it were sufficiently endowed with analysis and introspection, would demand.

In the previous discussion of Reason we found that at every experience we had to take into account not only the actual objects of experience in their own relation, but the nature of our previously acquired knowledge in all its inter-relations, and the original character of the mind in which the knowledge had been stored; so that the whole formed a vast complex, or resultant, with which the actual experience in question produced a new resultant. Belief, in this view, was not merely a contemplation of certain Associations but an attitude of the mind charged with impulses.

Now the Idealist, widening the scope of his own mind, may say that even the unexpected in the External world cannot be set down as objective, in the sense of being independent of the mind. He may maintain that in these new experiences he is simply developing unexplored regions of his mind; that the steps of a chemical experiment, for instance, are but the means, all expressible in ideas, by which he discovers new relations in the ideas of his own mind.

This mode of argument cannot be gainsaid, but there is no need in our desire for reconciliation why it should be. Instead of attempting to batter it in breach we have only still further to widen and develop it. We have to give to the possibilities of our own mind the whole scope of the possibilities of the External world as we can ever know it; and even in regard to the entirely unexpected, unknown, uncontrolled, we have only to hold all this as a factor which may be associated in any form with the complex of our stored-up ideas, in determining that resultant of which we have spoken, and the attitude of the mind towards the paths of its next possible movement.

In this fullest development let us consider the phenomena of what for convenience we call another

mind, although we are within the Idealist position of maintaining that this is part of our mind. But to that other mind we grant the fullest measure of the unexpected and of the uncontrolled, and we grant also that the means of exploring that mind are those of receiving instruction by the hearing, in connection with all the visual complexes by which we recognise a personality, or by visual sensations as in reading a book; and that the course of this exploration may lead us to ratiocinations beyond anything we have hitherto attempted, or may expand our spiritual sense, or even our ideas of our own ideality, beyond our previous conceptions; and we further grant that in our review of the External world we must think of other minds possessing continuity beyond any space of time in which we contemplate immediate experience. We thus see finally that there are no circumstances of the most abstruse speculation, or any character of imagination, that we cannot express in ideas.

But it is quite consistent with the Idealist position to make use of symbols, and to form all the combinations possible of the Fundamental Processes; and hence finally to speak of the External world in the easy language of every-day affairs. In all this, it must be noted, a distinction must be made between an Idealist and a Berkeleyan, for a student of the subject might find himself in accord with the preceding analysis, but in disaccord with many of Berkeley's conclusions.

But to what have we arrived in this way? Simply to the position of the Common Sense philosopher, if he also have pursued his common sense keenly and determinedly enough. He does not suppose that he can know phenomena of the External world, or of another mind, except by the means by which he can know anything; that is to say, he is dependent on his Pre-

sentations in their widest scope, entering into the domain of previous knowledge acquired by a mind determined by its original character and the total of all its experiences. Did he hold any other opinions he would be an Idealist, but of a wholly irresponsible kind.

It may be said that the Common Sense mind acknowledges the objectivity of the other mind, while the Idealist does not. But let us look at this very closely. The Common Sense mind must be restricted to this: That after all he cannot think with another mind, he can only think with his own mind, and that though he give to the terms "objectivity" and "other" mind the utmost independence, yet the expression of that independence is a mode of his own mind.

Let the Idealist on his part allow the exploration of his own mind to proceed to the limits of its capacity, and his attitude towards the unexpected, uncontrolled, in that exploration be the fullest expression of that possibility; then he will have no ideas different from those of Common Sense, for if any should be discerned he should widen still beyond them the region of the uncontrolled, or as we may say, without straining the meaning, the region of the independent.

Yet withal there may linger a sense of discrepancy. It is a real difficulty, and in removing it we shall find the last secret of reconciliation.

The Common Sense man says, I see a distant tree. By no means can I persuade myself that that is only an idea in my mind. It is an external object.

The Idealist may reply that as it is resolvable into ideas, the Common Sense man is wrong in regarding it as external.

But both in this regard fall into a tacit error of gross materialism. When the Common Sense man says that the tree is an external object, we may ask: External

to what? That it is external to his body cannot present any difficulty, for the Idealist could never suppose that it was in his body. That it is external to his brain is evident (cf. pp. 76 and 511).

But he replies, It is external to my mind. The true answer of the Idealist is not to try to persuade him that his actual view of the object is wrong, but to ask him, Where is your mind?

The brain is not the mind. Those who have advanced the idea of every mental act having its physical correlative have been accused of "materialism," but they are confronted with an assumption, even though a tacit assumption, of crude materialism both of the Idealist and Common Sense philosophers, that the mind is in the brain.

The Idealist who seeks the reconciliation, as there must be in all true things, says, Of course the tree is external to me or to yourself, as you behold us. But the tree is resolvable into ideas. The ideas are not in the brain. The ideas are where the tree, as known to me, is. The tree, as far as I know it, forms those ideas, or, as far as I know them, as ideas of the tree. That impression of Externality is the exact measure and account of the relation of those ideas, which are tree, to the other ideas, which are the interval between the tree and any object, such as my physical self, to which it is external.

We have already advanced beyond the position of Berkeley himself. Byron said of Berkeley, in an amusing verse:

> Though his speculations are too airy
> For the airiest human head.

But in departing here from Berkeley it is with the feeling that the sort of mystical paradox associated with him has arisen not from his subtlety but as a consequence of certain perverse misapprehensions of his own.

Berkeley, pursuing his own theories to practical conclusions, became opposed to the scientific spirit, as indeed have most of the idealists—Fichte, Carlyle, Emerson—though not so frankly as Berkeley.

They hoped to "evolve" out of their inner consciousness some particular revelation, as though the whole world were locked up in a human mind and could be expounded by diligent scrutiny. The extreme of this position has been ridiculed by Carlyle himself in reference to the Monks of Athos, who gazed intently into their navels in order to behold the spiritual world revealed.

All this is not merely contrary to the spirit of all that has made our civilisation great, but it is, again, the tacit acknowledgment of crude forms of "materialism."

For the Idealist who says, Why go to the outside world for instruction? is open to the rejoinder even from one he has instructed: There is no outside world—that is to say, apart from idea. What we are doing is to endeavour to find the clue to the sequence of our own mind. When we see a stone drop to the earth we are endeavouring, by active exploration and acquaintance with ideas, to trace the whole series of vast associated ideas between all the ideas of stone and of earth; but we shorten cumbrous language. Further, we say that the process of "evolving" ideas is one of spiritual energy, and does not consist in the restriction of the mind to the little plot that has become in any manner already "evolved." If the whole world be contained in the inner consciousness of the mind, we explore the mind in examining the world.

But we must now pursue the matter to the final issue. The Common Sense philosopher does not seem quite satisfied that the Idealist has yielded enough to make their views concordant. He says in effect: Sup-

pose that your mind becomes effaced; permanently, you may not admit as possible, but temporarily, you must acknowledge as often occurring. What, then, becomes of the External world?

The Idealist may reply that it vanishes. But then it is within his experience that he meets it again, constant in many parts, changing in others; all beyond his expectancy or control, all independent in as far as the Common Sense man himself can use the term. Who, then, thus uncontrolled, has re-created the External world?

The Idealist may stubbornly refuse to admit anything beyond something unknown in his own mind; but we have already considered the nature of Belief (cf. pp. 12, 329, 336, 337, 364, 377), and we have found that in the mind of man it has no immutable character, that in fact it is the resultant of myriad dynamic forces, some only of which appear in consciousness, and that it is expressed in a sort of dynamic representation of the mind towards associated new phenomena (cf. pp. 85, 377). This dynamic relation of Belief is the ground whereon we test the Idealist. He cannot hold or acquire the Belief that his mind is all, and that there is nothing objective to it.

But "by shoeing one becomes a smith," and by dint of analysing, Common Sense has become analytic. He demands to know what the Idealist means by objective, suspecting here also some discrepancy. He has noted, for example, that a tree gives different effects as tested by different means. It has a certain appearance in vision. It has another relation of gravity, as may be tested by weighing it. And if light from it fall on a photographic plate we find a certain image.

Is there, according to the Idealist, an unknown something which, in conjunction with the mind, produces an idea; or is the idea itself the whole something?

most complete independence, for the process of Dissociation is a process of my mind. I can also in this way consider my mind effaced, and yet the processes continued in other minds.

But this enlargement of the scope of his theory really means that Idealist has ceased to confine himself in ideas, and has adopted the Fundamental Processes as being necessary and sufficient for the explanation of all mental phenomena. Idealist, in other words, simply maintains that his mind can only think its own thoughts, and this every one will grant. Idealist, therefore, consents also to employ a form of language in accordance with the ways of Common Sense.

Common Sense, by persistent questioning of Idealist, has been forced to find a deeper and deeper base for his own notions, until at last, on the ground of the Fundamental Processes, he is able to avoid the errors that have heretofore arisen from mere superficial appearances. In this way the reconciliation is complete.

The argument will now be briefly resumed, it being understood that the positions are set forth here only for convenience of reference and that they should be considered in the light of the whole previous exposition.

Externality is capable of analysis. It is the result of the combination of impressions brought from all senses, and wrought into associations with previous knowledge stored up in a mind prepared by evolution through countless generations.

The position of the Idealist school is opposed to that of the Common Sense school. The Idealist says that the external world is a bundle of ideas. The Common Sense philosopher says that by direct perception one sees that it is substantial and objective.

The reconciliation is to be found in conducting the

analysis of both along routes which lead to deeper comprehensions and clearer views.

The Idealist must drop too narrow an interpretation of ideas in this sense. He must for this reason drop even Berkeley himself.

Various crude positions of the Idealist must be abandoned on the way: such as that his mind only exists; that the ideas of his mind sum up an object; that the brain is the mind; that an idea can have location in the brain.

The idea is where the object is, in so far as that object is known in idea.

To this it may be answered: We recognise the star Sirius as part of the External world; is the mind in Sirius?

The Idealist might reply that the question should really have been thus expressed: Is Sirius in the mind?

Before answering that question, I will take a more familiar case. I see the handle of a door. I desire to go out of the room, and I intend to turn the handle. But as I sit, I observe the handle. Is the handle in my mind?

In order again to answer that question we should have to retrace all the previous analysis. It becomes evident then that the question has been begged in the manner in which it has been proposed. I find that when I say, I see the door handle, I have present certain sensations, and part of these are designated by a symbol. By the very nature of the movements of the mind, we do not, when we use a symbol, bring to consciousness all that the symbol implies, but step by step, all that it implies may become duly developed to the mind.

Now the sense of Externality of the handle is immediately present, for it is implied in the symbol, and

the associations with all the complex of the senses involved in my consideration of the handle. Part of this complex is the series of the muscular sense, and the Feeling of Effort accompanying. I rise, and step by step as I approach the handle I am really developing what has been implied in the symbol, though this again is rendered more correct, that is to say, more in accordance with Nature, and more diversified and vivid by the actual new experience. Finally I touch the handle. I say that each step of that progress, in as far as I may have had consciousness of it, has been expressible as a mode of my mind; and at each step my mind has been where my conception of the reality was.

It is possible, however, to object that that is not the same as saying that the thing is where the mind is. Let us consider all that is implied in the objection. It will be better seen by taking another mind. That other mind may have conceptions respecting the handle that differ from mine. Factors of my conception may be entirely absent in another mind. Must there not be something constant in reality which may serve as a standard to show which is right?

To answer this question clearly we may go back to the considerations involved in a former question: Is the red I see the same as the red another person sees? To decide, can we refer to the actual red of the table-cover?

We are brought to the conclusion here that the red of the table-cover has no existence; that red is the result of the vibrations emanating from the table-cover, and the operations of the visual apparatus (cf. p. 77). And as we have noticed previously we converse of red because our sensations, though not the same, are correspondent enough for our purpose. In the case of the two maps previously discussed the correspondence itself

may be far from exact, and yet conversation may be intelligible (cf. p. 51).

But the notion is ineradicable that there is something objective, even if of a different kind to our sensations. Yes, and in our minds that is expressed by the something independent, something that brings new developments, and, in certain circumstances, even a fund of new sensations, something in fact that now, freely, and with a full understanding of the symbol, we may call objective.

But the positing of the symbol, objective, with all that it implies, is itself of the mind. We have required here, no doubt, a certain Process of Disassociation, such as we have discussed in considering Infinity. But that Process of Disassociation is not apart from the mind.

So now with Sirius. That is at first a symbol, and the symbol is where my mind is. But the symbol may have become developed step by step, and amongst its implication is that of enormous distance not possible to be traversed by my body. But step by step as I know of these matters I am knowing them by Processes of my mind, ultimately by means of Fundamental Processes based on Presentations of real things.

But the objector says: Sirius exists, quite apart from your mind; it would exist if your mind were extinguished. I reply that my knowledge of Sirius would be extinguished with the extinction of my mind. When you say it exists you posit another mind. But my extension of Idealism has enabled me to posit another mind, and to speak of what that other mind knows. I hold that all that I can know of Sirius is all that Sirius is as far as I can know.

Then the objector cries, At last we have the real paradox. Is there not a difference between all that

you can know of the world, and all that the world is, as possible to be made known to you?

Here I recognise the veritable crux. We are face to face with a paradox again as deep, and as fundamental apparently to our powers, as that of Infinity. We solved that of Infinity by a Disassociation, or leap of the mind, with the formation of new Associations. We found that we had to stretch finity to infinity if we desired to compare finity with infinity. Similarly here we must stretch the meaning of the term "independence," or objectivity, to the extent that the mind can only appreciate it by a Process of Disassociation, even though it recognise that Process, and the subsequent Process of Association, step by step, as Processes of the Mind.

Having then kept the Idealist uncompromisingly to his own Idealism, and pursued with the utmost energy his own well-begun but timidly abandoned analysis; having illuminated Common Sense and compelled it to sacrifice all that was not, in the clearest vision and with the aid of deeper analysis, consistent with fundamental Common Sense; we may declare that all that a mind can know of the world is known through the modes of that mind; that still the External world is real and external; that we reach, at the limit, something indistinct of separation, which we can bridge by a leap whose character we know as a mode of the mind; and that henceforward we speak of the External world in the familiar terms of Common Sense. And withal we must observe that the ultimate limit of division between illuminated Common Sense and determined Idealism is so indistinct that we cannot say definitely whether the leap spoken of is necessary, or whether it differs at all from that discontinuity which is always in the mode of movement of the mind.

CHAPTER III

EGO AND WILL

§ I. Synthetic Example of the Exposition of Will and Ego

We may now select some simple illustration by means of which to refer in more synthetic form to certain positions already discussed, and to observe arising in the discussion the forms of the Will and of the Ego.

A child sees a live coal.[1] He sees it at first altogether as a Unit. He stretches out his hand and touches the fire. He starts back in pain. This incident could be made the text of volumes of matter, for it opens up the whole ground of Psychology. Into the question of Locke's *tabula rasa* (cf. p. 26), or the doctrine of innate ideas, there is no necessity further to enter.

[1] The psychology of children has been studied with particular attention of late years. In addition to well-known names such as those of Darwin, Preyer, Romanes, A. F. Chamberlain, Wundt, Höffding, Baldwin, Pérez, and Störring, we find more recently Egger, Lindner, K. C. Moore, Oltuszewski, F. Tracy, Fr. Warner, Clara and William Stern. Amongst psychologists who have particularly directed their studies to the language of children may be mentioned F. Schultze, J. Dewey, E. Noble, E. A. Kirkpatrick, H. T. Lukens. The famous mathematician, Sonia Kowalewski, studied her own childhood; Pérez has written on the first three years of childhood; Elizabeth S. Brown deals with "The Baby's Mind"; A. Kussmaul has published "Untersuchungen über das Seelenleben das Neugeborenen [new-born] Menschen"; H. Fehling has studied "Das Dasein vor der Geburt" (Being before birth); and old Sir Thomas Browne gave a delightful philosophic conversation between twins who were waiting to be born. Treitel, A. E. Tait, and Dr. Eva McCall have written on Aphasia in children.

With respect to the movements of the child it must be noted that many of his efforts result from no particular stimulation from without, but from abundant impulses within the brain (cf. pp. 5, 6, 80, 81, 85, 336, 560). The child's brain is a magazine of energy which does not completely explode because to each impulse there is an inhibitive or controlling power. Sometimes the locked-up energy escapes control. We see this in an unhealthy form in St. Vitus's Dance and epilepsy, and in a healthy form in the lively play of young children (cf. p. 81).

Superadded to this, however, are the definite impulses due to pleasurable stimulation. The child would like to get the live coal, because its brightness is pleasing. He sprawls about, but he gets nearer. The sprawling is due to lack of co-ordination of the muscles, but in this sprawling he is helping his growth and educating his brain.

The difficulty of co-ordination may be seen in a man of advanced years attempting to learn an intricate dance. His case is more difficult, for he has to thresh out new brain connections, whereas the child has but to develop his natural growth (cf. pp. 249, 277, 292, 348, 364).

There is in the movements of the child the counterpart of instinct (cf. p. 423). If the live coal were pleasant to handle he would probably put it in his mouth. In judging the instinct of animals we must remember that the world of smell, as in a dog, is an immensely more various and discriminated and more powerfully stimulating series than with us (cf. pp. 58, 65) and that the propulsion of the muscles which follows thereupon is a matter of less strenuous exertion. A dog hunting on the trail is kept going by the persistence or the increase of the same kind of stimulation serving continually to produce the same kind of action. The action of a child sucking a lollypop is of the same class. The action of

the child in sprawling towards the bright object introduces no extraordinary element; but we will see that from this experience we shall be able to talk of Reason. There is no line of separation between instinct and Reason.[1]

The question of instinct will be here briefly dealt with. For convenience of reference the matter may be expressed:

1. In the study of instinct importance should be given to the fact that certain animals have a great range in regard to some one sense or other, or possibly to several senses.[2]

2. At the basis of our reason, that is to say, in the Fundamental Processes, there is an analogue of instinct; for, the conditions being present, the functions are produced automatically. This may be seen in Association of ideas.

3. The whole scope of application of Association

[1] A symposium on Instinct has recently appeared in the *Journal of Psychology*. An article by Wm. McDougall seems to me especially good. Lloyd Morgan and Dr. Myers express views in general accord with those set forth here. McDougall laments that Stout rejects human instinct. Willdon Carr follows Bergson, and with him I find complete disagreement. It will be generally found that those who have actually studied animals are the least inclined to make a barrier between their faculties and ours by virtue of instinct. In a study of protozoa (Hodge and Aikins, 1895) Hodge expresses the opinion that even unicells have some form of consciousness.

[2] The experiments of Galton, Hachet-Souplet, L. Edinger, Ed. Claparède, and others are instructive in this regard. C. Groos on the play of animals may well be consulted. In addition also to well-known standard works such as those of Lamarck, Darwin, Lord Avebury, Ch. Bonnet, and others already cited, we may note for curious interest such researches as that of W. Wagner, "L'Industrie des Araneides," and J. H. Fabre, "Mœurs des Insectes," and some elaborate studies in American Universities on the White Rat (Small), the Educability of the Perch (Triplett), "The Animal Mind" (Mary Floy Washburn), and allied questions. Note also, in regard to human capabilities, Arthur Carr, Honorary Secretary to the Blind Social Aid Society, says: "I know a man who though quite blind can tell the height of buildings, through his keenly developed sense of hearing." L. Truschel has quite recently investigated this matter elaborately and has concluded that the perception is due to the refinement of the appreciation of sounds.

must be widened. There becomes ultimately involved the consideration of the entire sensory and motor conditions of our existence.

4. In considering the manner of corresponding associations in animals regard must be shown to the different intensity of emotional states associated with certain objects, and the different constitution of the associated motor conditions.

5. Even before previous individual experience there has been developed throughout the existence of the species a ground-work that determines the subjective character of the experience.

6. On these general lines an exposition might be set forth that would show no break of continuity of evolution from instinct to the highest grade of intelligence.[1]

The child touches the live coal, and starts back with a look of affright before he has even properly appreciated the sensation of pain. A great many questions which cannot all be discussed here have been opened up. The expression of the emotions is of interest to us, for it shows to us that the effects are not confined to a single strand of nerves. The shock sends a storm of explosions throughout the brain and thence throughout the body. The whole action has been involuntary—the starting back, the shaking of the body, the straining of the muscles of the countenance, the catching for breath, the cry. Then follows a definite feeling of pain.

The child has made a very impressive experience. It is but a type of the whole world of stimulations of pleasures and pain by which our actions are influenced. Some of the more subtle of them, it is true, could never be analysed in terms so plain as in our example, but to

[1] Professor Lépinay, whose lecture at the new Dogs' and Cats' Home near Reuil has been already referred to, is of this opinion. Many other eminent scientific men have held the same views, but I do not wish to impress their mere authority.

these it stands in the same relation as instinct does to Reason, or the rudimentary stage of an organism to the developed creature.

If we attempt to repeat the experiment, the child starts back before actual contact, and the whole process differs from the first in being more subdued and in losing altogether some of the minor features. Again, a number of interesting problems are opened up. We are face to face with Memory. Repetition of a process produces facility of conveying stimuli, but the ideas corresponding to the Presentations in Association produced by the original storm are weaker than the presentations. They give to Memory the features by which we know it.

The original experience brought vivid Presentations in Association not only of the live coal, but the general appearance of surrounding objects. The ideas of these are subsequently less vivid, less persistent; and they are moreover overswept by the Presentations of the immediate reality.

Let us consider a slightly different example. We see a lamp on a table on which are books, ornaments, or other objects that also attract the attention. The impressions we receive are more than the sum of the sensations, for these Immediate Presentations have not only definite and intricate relations between themselves, but also they are associated with previous experiences.

Now let us suppose that we behold the same lamp at another time and on a different table. The Immediate Presentation of the lamp has a correlative in the same centre in the brain as before; and because the paths have already been opened up and so made more facile, those parts of the brain become awakened to activities which correspond to the image of the table that was associated with the lamp in the first case.

Thus there is then the Immediate Presentation of the lamp repeated, and the image of the table similar to, but not less strong than, its former presentation. But also there is the Immediate Presentation of the second table which at once overrides and submerges the image of the first, and continues to respond to all the tests of reality, viz. Association of Presentations from all the senses, and capacity for yielding new sensations. Thus though the increased facility of responding to stimuli like those producing a previous sensation is the essential of Memory, yet Memory is made known to us by the ideas in Association; and the distinct Memory of a specific object is rendered clear by certain ideas persisting while others fade and become replaced by a new set.

It may happen that the recurrence of our experience may give a peculiar agitation to the mind, but which in its vagueness may not seem to us definitely to be of the kind to which we apply the term Memory. Thus we often say, "I am almost sure I have seen that face before, but where?" (Cf. remarks on this subject in the chapter on Memory, pp. 283-285.)

In such a case the facility of surrounding paths eventually leading to present realities has not been great enough to produce definite images in Association with those reproduced, but the stirring of these paths makes itself known in consciousness.

In other cases there may be a definite Memory, but it may not be possible to establish whether a certain experience thus revived in the mind was before or after certain other experiences. What there is needed for a complete recollection is not only the Association with definite images, but also a continued Association of such images with experiences that lead by recognised sequences of time up to the present reality. There

may be all grades between this and an unconscious capacity for receiving stimulus more readily.

Suppose now that for the live coal in the experiment we introduce something closely resembling it, say a ruby. There is on the child's part a great repugnance to touching it, and the approach brings up a gathering and painful storm; but when the finger is actually brought into contact with it there is a sudden collapse of the agitation and the entry of a new set of sensations. This shock of surprise is agreeable, and the activity of interest impresses the incident on the mind (cf. pp. 397, 419, 423).

Such a shock of surprise contains the elements of one kind of humour. Another kind is formed in the collapse of an elaborate expectation of pleasure, but in such a way that any feeling of pain is small in comparison with the mind's capacity for recovery. The essential point in this also is not the disappointment of the expectation, but the recovery from the disappointment.

An example a little more complex than that of the child is where at an evening party a young man rises to sing and finds that some one has tied his coat-tails to the chair. He turns round, sees what is the matter, extricates himself and joins in the laughter of the company. If he had been unable to rise on account of a paralytic stroke, it would not have seemed at all humorous. The humour does not arise until the pleasurable features have submerged the others.

If now we consider humorous recitation we shall find that the elements of humour are here similar. Take Hood's little piece, "We're putting a gaspipe down." A reciter works up the feeling of mystery and horror, then comes the homely fact regarding the gaspipe.

The pleasant surprise of a relief from the tension of overwrought feelings accounts for the success of judicial jokes. Remarks, not apparently very humorous, let fall from the judge, often cause great merriment in court, except possibly to the parties against whom they are directed. For example, an Irishman condemned to death asked Lord Norbury for a "long day," meaning thereby a long interval between the sentence and the execution. The judge replied: "Yes, to-morrow is the longest day of the year. You will be hanged then." This sally of wit amused the court, but would appeal only to a prisoner exceptionally gifted.

It will be observed that the appreciation of humour depends not only on the form of the humour itself but on the attitude and temperament of the individual.

For example, if a young man who had his coat-tails tied were a nervous and sensitive young man, his state of painful embarrassment might exclude any sense of humour. At the other end of the scale we have the story of the Irishman who kept laughing while he was being flogged. He explained that they had got hold of the wrong man.

For some kinds of humour a certain kind of fortitude is necessary, for where painful incidents occur we have noted that the capacity for recovery must be elastic and extensive beyond that scope.

Hence it is that humour, and good humour, are often conspicuous in men of great courage and strength. The appreciation of humour is also influenced in individuals by the degree in which they enjoy laughter in itself. If in addition to this there is found considerable fortitude in bearing the pains of others, unusual incidents of humour may arise. Thus three Burmese were sitting on the bank of a river as a gunboat went up. A cannon-ball from the gunboat took

off the head of the middle one. The other two laughed consumedly.

We may carry the principle even to the consideration of such a book as "Don Quixote," where the humour is not merely in the incidents but pervasive throughout the whole conception of the story. Here we have the colouring of the mind of Cervantes himself, who, an idealist, had found how often the ideal becomes defeated by its own extravagance; and, with a philosophic appreciation of things at length, "laughs his life's regret."

It seems then that the most subtle sports of humour might be typified by this example of the child, just as the processes of Reason may also be indicated from the child's experience.[1]

Considering the child once more, we find that in the experience of a ruby which he mistakes for a live coal, and towards which he places himself in an attitude corresponding to that belief, we have the Process of Agreement. But when he touches the ruby, Discrimination arises by the negative of that Agreement in certain particulars (cf. p. 29). What particulars are still contained within Agreement afford the grounds of a Generalisation which admits of a classification by taking into account also the particulars discovered in Discrimination. And we have also symbolisation, for that is the mode in which we obtain the terms "live coal" and "ruby." The child, though not acquainted with these names, symbolises nevertheless. Its symbols are formed by visual appearances perhaps in combination with the indications of other senses.

When our experience is repeated, and when certain

[1] One might expect from what has been said that humour might also be found in animals. That is certainly the case. I have made some study of the matter in papers published elsewhere.

sequences are observed to be invariable, the tendency is to symbolise a whole plexus of Presentations and ideas by means of the first clear indication—formed by Presentation and associated ideas—of the plexus following.

For example, in writing I dip my pen again and again into my ink-bottle. Temporarily I am placed in a fairly constant dynamic relation to all my surroundings, and if I require to fill my pen I find it sufficient to glance up and observe an indistinct black object—really my ink-bottle—and without thinking take a dip. If my attention be drawn to the matter, I find it possible to make an elaborate analysis.

Or if I have observed a donkey in a neighbouring field, and if I have seen him every time I have directed my eyes there; then if, on another occasion, I notice two ears sticking up beyond the hedge, I say the donkey is still there.

All this is in accordance with what we have repeatedly observed, that ideas in Association have the facility of their Association increased by exercise. The facility of the paths of the physical correlative is likewise increased. This process is automatic and inevitable; it is what we have called a Fundamental Process (cf. pp. 46, 344, 401, 412, 414, also 93, 114, 159, 423).

The child is not singular, therefore, in using symbols, although not yet acquainted with words. Such an observation should be borne in mind in studying animals; for though in order to express their meaning they use their own words, which are complex symbols produced by a combination of muscles acting on a sounding apparatus and producing their effect on hearing, they also use other symbols, some of which produce their effect on the visual sense, and are formed by combinations of the movements of other sets of muscles.

Even in highly developed regions we find men working with symbols of their own. John Hunter, the surgeon, and Turner, the painter, are curious examples of men profoundly versed in their respective subjects, but deficient in the power of making their subjects clearly intelligible.

Turner, especially, when endeavouring to discourse on art, seemed to be incomprehensible. The explanation is that, his study of art having been greatly original, he was not conversant with the phraseology of the schools, but was accustomed to think of certain things by signs and names of his own. Hence he was in nearly as difficult a position as if he were speaking in a foreign language with which he was little familiar.

The Feeling of Effort is manifest in the energetic manner of appreciating sensations, while the Impulse is shown by the recoil of the child when lack of Discrimination had produced false routes of ideas in Association. The Hedonic principle is indicated in the character of the sensations. The succession of Time is also appreciated, and the forms of Space at each Presentation. The Unit varies at each moment of attention.

If the experiment with the child be repeated, there will be a conflict between the two Impulses. There will be a hesitation in action. With the interest awakened there will be a closer attention, and with the new experience there will be a certain Discrimination of the ruby as distinguished from the live coal. Here we have a complete example of reflection and of judgment (cf. pp. 353, 419).

Reflection is the operation of the mind, by which the diverse factors of a question are considered; and these factors are resolvable into the Fundamental Processes applied to the definite objects and ideas. Reflection prepares the way for belief (cf. pp. 12, 336 *et seq.*, 364

that the Hedonic principle is involved in the elements with which Reason has to do (cf. p. 423, also pp. 349, 356, 362, 441); and, moreover, that it is the limitation of the scope of our faculties which forms the condition for the existence of Reason (cf. pp. 53, 93, 197, 207, 337, 364, 372).

James Mill analysed Will into what we may briefly speak of as something of this kind; the recognition of that feeling of pleasurable excitement which has in the conflict of feelings proved itself to be the strongest.

This analysis has been accepted by most of those influenced by the Utilitarian school of the Mills and Bentham, or by the Hedonistic school of Herbert Spencer.

Of course the term "pleasurable" must bear no restricted implication. Yet even so the analysis does not appear to me adequate,

We have seen in the case of the child, in one of the simplest examples we could find, that the Impulse corresponding to a certain path of ideas in Association could overcome, if not the impression of pain, at least the weaker impression of a possible danger.

In this case there does not seem to be clearly defined a balancing of possible pains and possible pleasures with the resolution of selecting a certain course of action accordingly. Or if confusion arise by what has been said about judgment, we may go back to the original incident of a child and the live coal.

Here we saw the child sprawling towards an object whose properties were for the most part unknown. Certainly the brightness acted as a pleasurable excitement, though another child might have the sensation of brightness as acutely but not a similar Impulse to action. The Impulse to action depends on the whole constitution of the child (cf. pp. 5, 85, 95 *et seq.*, 346, 357, 397, 420, 567), and the brightness is not so much

a cause which sets in motion the whole machinery as something which removes an inhibition or disturbs a temporary balance. To continue the metaphor of the machine, the stimulus removes the catch.

When the child touches the live coal he starts back. In this case there is no weighing pleasurable and painful emotions. The shock comes before the clear sensation of pain, and the storm overrides the weaker Impulse derived from desire.

The decision has been automatic. But it must be remembered that, when the conditions are determined, the Fundamental Processes are likewise automatic (cf. pp. 52, 93, 114, 172, 234, 423, 576).

When we speak of any process being automatic, or sub-conscious, we do not thereby relegate it to a realm of hazard. The physical correlative of this has been formed by processes of Evolution, by the selection of resultant forms which have been proved the best adapted to safety in experiences of which that of the child is a type.

When the child sees the ruby, the ideas and the Impulses associated with the storm rise up, but the Impulses produced by the brightness of the object are strong. Moreover, the repelling Impulses depend on Memory, and they are therefore weaker than the original, and Discrimination has operated on account of increased attention, consequently the Impulses tending to make the child touch the object begin to prevail. The Impulses are continually receiving fresh stimulation.

Here we see in an elementary form a factor that must always be taken into account in considering Will. The continual repetition of an incentive under circumstances of fair constancy will often cause a man not remarkable for will-power to accomplish a considerable undertaking.

When the child's new experience is completed it has added something to its stored-up knowledge which modifies the previous resultant (cf. pp. 105, 320, 370, 380, 504, 570). It has found that some present pain must occasionally be faced and overcome in order to obtain a future benefit; but this is not registered simply as a matter of profit and loss to the account of pleasure and pains.

There is an immediate satisfaction, or Hedonic principle, in the resisting of contrary Impulses, as in overcoming pain or putting forth new exertion.

This principle is stronger in some natures than in others, and it has a direct dependence on the vitality and energy of the person. It is one of the rudimentary factors of the great incentive of ambition, and is, as moreover ambition may be when not directed to selfish aggrandisement, one of the noble qualities which have their sanction deep in human experience and in the factors that have made human greatness.

For the same stimulus, pleasure and pain differ in individuals, and this difference also depends on the vitality and vigour of the individual.

Every subsequent experience of the child will not only give it fuller information of the world, and extend in its stored-up knowledge the Associations between ideas and emotions of all sorts (cf. pp. 525 *et seq.*); but it will help to form habits according to the physical condition, the general character, and temperament of the individual. These habits are as important in regard to Will as they are in regard to Memory (cf. pp. 49, 220, 261 *et seq.*, 328, 383, 395, 526), or any other form in which Association has part.

They indicate too that in the same sense in which Memory can be cultivated the Will can also be cultivated. If we extend the comparison we note that Memory has

been considered as not a distinct faculty, but as appertaining in its peculiar quality to each idea. Will, according to the mode of representation we have arrived at, would be manifested as the resultant of a combination of Impulses, against contrary Impulses, and each of these Impulses has its own peculiar force.

But the case of Will may appear to differ from that of Memory in that we have to deal with a combination of Impulses, whereas in Memory, though the recollection depends on the force of a number of ideas in Association, yet the idea to be sought in Memory is single.

The difference is mainly due to the use of popular language wherein Will is taken to imply some massy resistance; but in every conscious act, even the most simple, there is an expression of Will.

We have been led in the study of Memory, also, to find that though some individuals have generally strong Memories, and others weak Memories, yet it may be possible that the Memory is weak with respect to one set of ideas and strong in another region.

We find similar conditions in Will. Some individuals who are taken as types of strength of Will, because in the regions in which they exercise their faculties conspicuously their Will is strong, may yet be weak in Will in other directions hardly less important to their existence.

General Grant, whose iron firmness crushed down the resistance of the South in the great Civil War of America, had before the war become a wastrel. Subsequently elected President of the United States, his career was such that I have heard him described by an American student of politics as a "weak man."

Some of the old prize-fighters displayed force of Will which Sparta or Rome never surpassed, but their Will was weak in other ways. Jem Ward was described as a lion in the ring, a child outside.

Bonaparte, who at Arcola had again and again by the force of heroic example strengthened the wavering resolution of his soldiers, himself wavered on more than one occasion where his brother Lucien displayed tenacity of purpose. At the scene of the expulsion of the members of the legislative chamber on November 9, 1799, Bonaparte required the support of the will of the Abbé Sieyès, which, in the circumstances, was stronger than his.

The effect of habit on Will is illustrated by one of the delightful series of Georges d'Esparbès in his "*Guerre en Dentelles*" ("War in Lace and Frills"). A French officer, during a period of war with Frederick the Great, disguised himself and acted as spy. Having been taken prisoner, he was submitted to various ordeals, which he met with Stoic fortitude. Accidentally he stumbled against a lady, and, forgetting his assumed character, he made a courtly bow and begged pardon in French.

As a contrast with Napoleon's failure to rally after Waterloo, a failure which had many causes, the example of Blücher after Ligny may be cited. Blücher was far from being the equal of Napoleon in intellectual power, but his general temperament formed a factor strong in Will, and familiarity with defeat had rendered the exercise of Will more definite and determined under such conditions. Hence followed the tactics which ensured victory for the Allies at Waterloo.

A man of indomitable Will, as an explorer, for example, might well show indecision if called upon to perform a surgical operation; while a surgeon, otherwise of weak character, might take charge of the proceedings in a style of masterly command.

In the case of the surgeon there has been a training which has defined the objects met with, which has again

and again regulated Impulses along appropriate lines according to the ideas in Association, and which has at length formed a strong habit.

In this way we see a new meaning in the aphorism, Knowledge is Power.

There are many cases in which an individual may continue in the performance of acts which produce pain, even to the extent of being fatal, but which we do not consider as evidences of Will. For example, a maniac may dash his head against a wall, or an epileptic throw himself into the fire.

In such cases we may say that the mental derangement confuses the feelings of pleasure and of pain. But no one considers that the maniac balances pleasures and pain and decides, on a wrong calculation, to dash his brains out. The maniac and the epileptic are carried on by Impulses which they cannot control.

We have other examples in which the consciousness is much less disturbed, as in hysteria. An individual may have been brought to a condition of hysteria by an inordinate pursuit of pleasure, taking the meaning of pleasure at a low standard. But in a certain state of body and mind the hysterical individual may persist in acts which give a great amount of pain. Or by remaining passive, as if paralysed, the hysterical individual may suffer grievously.

In neither of these cases do we speak of a strong Will. We say the state is due to a deficiency of Will. In the first case the dynamic forces are in a state of excitement, and the inhibitory power is weakened (cf. pp. 85, 236). In the second case the whole nervous energy is weakened, or its exercise obstructed in some manner.

In dealing with reason we have observed examples of authoritative association (cf. pp. 357, 503), and we

have also observed that mental excitement has its counterpart in physical excitement.

An instance may be given where authoritative association produced physical results in hysteria. It was related to me by Jean Charcot, the celebrated Antarctic explorer, as having occurred in the practice of his no less famous father. Dr. Charcot had as patient a young woman who, though physically sound, as far as could be ascertained, believed that she was unable to rise from her bed. Her malady had been caused in part by excessive reading of religious books, and she had a particular respect for St. Peter. Dr. Charcot simulated St. Peter and, presenting himself to the patient, commanded her to rise. She did so, and that was the starting-point of a cure.

The fakirs of India, though apparently not men of great vitality or mental vigour, train themselves to resistance of feelings of pain to an extraordinary degree.

Having therefore seen that either by training, or some severe stress, it is possible to produce states of body and mind where the usual standards of pain and pleasure, and their effects, are greatly modified, we will return to a closer consideration of Will.

In ordinary language strength of Will is not considered as coming into play in listening to sweet sounds, or in the soft enjoyment of a warm bath. We hardly speak of strength of Will in the active pursuit of some infatuating pleasure. We think of Will rather in connection with an arduous and long-continued struggle against difficulties. When the Roman youth, in spite of terrible protests of pain, holds forth his hand in the flame to be burnt, we speak definitely of Will.

The reply of those who explain these matters by the pleasurable impression being superior to the painful, is

that even here there is the pleasure of conquering the tyrant, and of performing a service to one's country. But arguments of this kind really beg the question. For if everything that produces action be called pleasure, then it is evident that pleasure must always be the cause of the actions.

Moreover, a weaker individual might have the stimulating feelings of high sentiment in equally powerful degree, and have as keen a pleasure in their realisation, and yet be conquered by the pain.

But if during years previously, and especially in the earliest years, a vast body of ideas in association be built up around even the pleasurable incidents of love of country and victory over tyrants, and if these associations be strengthened by symbols and linked, not only to the early mental constitution, but also to the projects of a man's life, then all this will form within the mind a factor from which the effects of authoritative association will flow.

The immediate Hedonic principle must not of course be minimised. The Christian martyr whose body, smeared with honey, was stung to death by bees smiled down on his human tormentors. He felt vividly that he was enduring but a painful passage to an eternity of bliss.

The Mahommedan who flung himself from a precipice at the bidding of his Sultan to testify his faith had within his mind the image of the waving green handkerchief and the love-light of the houris in his eye.

The case would be different if they felt nothing but the "silence of infinite spaces," though even then martyrdom to a cause of negation is possible by reason of the strength of the other factors.

We see then that the Will is not to be summed up

in the balance of pleasures and pains; and especially, that we must not give a limited interpretation to pleasures and pains. In each case of the exercise of Will we must consider a resultant formed in the mind by a multitude of factors: the original constitution of the mind, its vitality and energy; the strength of its Impulses; the continual testing of this as against contrary Impulses in every act of life; the combinations of these; the appreciation of opposing Impulses formed in knowledge by experience; the immediate Hedonic principle in overcoming resistances; the habits formed and made organic; the associations formed with symbols that have powerful associations already woven round them; the stirring up of a fund of authoritative association in this way; then the immediate Hedonic principle in the Feeling of Effort itself, in the display of power against resistance; the refined pleasurable feelings of high ideals; even the potent promptings of vanity; then the force of dynamic Impulses which are beyond control. Such are the factors that enter into the formation of Will.

It may be questioned whether there is not something more in the Will than is here set down, something that gives to the Will a more distinctively ethical import. There is nothing in what has been hitherto discussed to exclude such a supposition.

It must be remembered that the ultimate cause, and the ultimate sanction, of all our Processes, and therefore of all their combinations, escapes our analysis. Once the conditions are determined sensation arises, or Memory makes itself known, in a manner which is independent of our desires, or our Will. We may say that when the conditions are established they arise spontaneously, if the meaning of that word be defined according to what has been said. In this way also

the Impulses arise spontaneously. Why? The solution of that problem contains the unknown factor which may bear the true ethical import.

Moreover, in the course of our evolution our whole constitution has been developed in such a way as to prepare certain conditions for these Impulses, and the course of our development has contained factors beyond our desire or our Will.

We are caught in a sort of Universal movement which moulds us and carries us on to certain destinies. Is there purpose in this, such as finds expression in whatever is true in our ethical conceptions? Who can say that there is not?

The discussion of such subjects leads beyond the scope of this book. I have set forth the analysis of factors which come clearly within the scope of what we may know in Psychology; and certainly the analysis has been carried beyond the positions of James Mill or Spencer.

The discussion of Will, however, is not complete till we have considered the Ego.

§ III. The Ego

Let us return to the study of the child in our experiment. He sees his finger some distance away, and he observes that when the finger is brought in contact with the live coal, or the ruby, distinct sensations arise.

By continuing his experiences he observes that when the other parts which he recognises touch the object, sensations arise. He also observes with respect to the ruby the conditions that we have discussed with respect to the stone (cf. pp. 88, 89, and p. 552); that if a movement be applied to any part of it, the whole plexus moves together

These conditions facilitate the conception of Unit, as applied to the object.

Similar observations are formed with respect to the part of the child's body. He observes a continuity in all the parts, and he observes that from any part may arise sensations.

He observes that when he turns his head he loses sight of the ruby, and that also when he places his hands before his eyes he no longer sees the ruby.

In this way by incessant experiences he explores his own body by the use of the same faculties as he has examined the live coal, the ruby, the table. There is nothing transcendental to tell him that any part of his body belongs to himself. In point of fact he will never arrive at the complete knowledge of the parts of which his body consists. Most people know only superficially of what constitutes the body.

Similarly he finds by experience the relation between his sensations and feelings. We have already seen that nothing apart from experience tells him inevitably of the relations between sensations of touch and those of sight (cf. p. 552). But step by step the experiences are made under normal conditions, and these are facilitated by the whole constitution of the child. It may happen that certain of these experiences cannot be made by the child—as, for example, if he be born deaf or blind, his world is limited accordingly.

But it may be said that what the child, so limited, knows of himself is his whole Ego. That is not the case, for the obstruction to his senses may in some cases be removed, and the child discovers new faculties within himself. He may never discover the whole range of his sensations and feelings. Certainly he will never discover the full scope of their possible combinations.

If children be studied it will be found that their remarks often reveal the vagueness of their conceptions of their own personality. A child, for example, who was peevish on a certain occasion afterwards explained that she had a pain in her temper.

A child suffering from ear-ache pitied her ear, as she might pity another child whose sufferings were vividly brought home to her. She cried: "Oh, my poor dear little ear!"

The process of education is helped by the instruction of others. She had been told that she had an ear, and an eye, and a finger, and a temper, and a bull-dog. She thought that she might have a pain in the temper as well as in her ear, she thought that it belonged to her somewhat as the bull-dog belonged to her.

A further illustration of the manner in which the conception of the Ego is formed may be found in this study: The same child told another still younger that she ought to be "good."

This one demanded: "Why?"

The elder child, puzzled for a moment, at length replied: "Because you have an immortal soul."

This conception had hitherto been unknown to the younger child, but she endeavoured to adjust it to what she had previously learnt by experience and teaching of the Ego.

The exposition here given of the growth of knowledge of the Ego is at variance with the assumption of Descartes as the basis of his system: Cogito, ergo sum.

But both the Ego implied in the "sum," and the "cogito" are complex. Further if "cogito" have the meaning Descartes desires, the Ego is already implied in "cogito."

Certainly the new-born child when it utters its

first cry on contact with the world does not open the ball in these terms: Cogito, ergo sum.

Moreover, it would be merely begging the question to call the sensations it then experiences a conception of the Ego. It experiences the sensations at first with no definite relation to the other senses which are ready for activity. But the sensations take place in an organism prepared for development within certain lines. The process of that development has given the whole material for discussion in this volume.

§ IV. The Ego and Will

As the child sprawls towards the ruby his movements are not altogether accidental. He is so constituted that the desire to reach the ruby tends to produce direction and co-ordination of movements necessary to the fulfilment of that desire.

It may happen that the Presentation of an object, or combination of objects, may produce co-ordinations of movements that are not controlled, and not entirely represented in consciousness, and not even directed to the fulfilment of any desire.

For example, a dachshund which had been taken from his parents when very young, and which had never barked nor heard another dog bark, was playing with his master when suddenly in the zest of the game he uttered a loud bark. He started back in surprise and alarm, but presently, finding that no unpleasant consequences happened, he repeated the bark with great enjoyment.

In the first instance, though there may have been a Feeling of Effort, we could not speak of the effort itself as being due to Will, nor even to desire (cf. pp. 5, 85, 235, 567).

We will return to the consideration of desires, but there are certain aspects of Will now suggested that deserve to be discussed.

If any effect occurs frequently associated with efforts of our own, we are inclined to think of the effects as having been produced by these efforts.

This is probably the origin of our notions of cause and effect in which we have a tendency to see more than mere sequence, and to which we ascribe some sort of anthropometrical action (cf. pp. 8, 9, 204, 330, 387, 391, 444, 693, 718). There may well be in cause and effect something deeper than mere sequence, even if invariable, but that has not been made known to us in consciousness; while to speak of force with assumptions derived from Feeling of Effort is simply a case of the error of Involved Association (cf. p. 494).

But when our Feeling of Effort is involved the tendency to think of cause and effect is so strong that we are apt to apply it even when the sequence is accidental. It is difficult to arrange any experiment that will show this, for the individual should not know that the sequence is accidental. If, for example, I move my hand to a certain position at regular intervals, and a shadow appears on the wall, I regard the shadow as due to my hand. If I allow an interval to lapse and the shadow does not appear, my opinion is strengthened. And if the shadow reappears again when I move my hand to the former position, I shall have a strong belief that the shadow is dependent on my Will. But the effects may have been due by some rare coincidence to another cause.

Or again an individual lying in bed on a quiet night hears a rustling sound. He thinks it may be due to his breathing; he stops breathing, and at the same time, to listen better, removes his ear possibly

from the place at which it could well hear the sound. The sound ceases. He resumes his former position, and recommences breathing. The sound reappears. He becomes convinced that it is due to his breathing, and therefore in some degree dependent on his Will.

We cannot tell except by experience how far any effects are due to our Will, or what kind of phenomena are associated with any Feeling of Effort.

The observation of the dachshund proves this. But other indications are not lacking. The child finds that it moves its arms in correspondence with a certain effort; but if the arm be paralysed no visible effect would follow the effort.

Even when the character of the phenomena are known it is only by experience that we can know what degree of external effect will be produced in accordance with a certain effort.

A great part of physical training consists in adapting the lessons of experiences of the kind. For example, a boy bowls a ball, and it falls wide of the mark. He observes in what way his effort has been too great, and he tries again. Repeated trials, with increasing accuracy, at length form a strong bond of association between his conception of distance and the effort, or rather the co-ordinated efforts, required to toss the ball correctly to "get the length."

Similarly a singer, training the voice with regard not only to volume but also to pitch, can only be guided by experience, the fortunate tentatives being chosen for particular attention, so that a strong bond of Association is formed between the required sound and the various co-ordinated efforts of the different muscles required to produce the sound.

If now we return to the child we find that among the various sprawling efforts not entirely controlled

but nevertheless influenced by the desire to appropriate the ruby, some are better adapted than others. The representations of these become impressed on the child's mind in association with the efforts corresponding. The next efforts will be more consciously directed. This sort of education proceeds with every fresh experience.

In the first "spontaneous" movements of the child we do not speak of Will, as in the unexpected bark of the dachshund we do not speak of Will; but when the effort is consciously directed to a definite end, we speak of Will. The child finds pleasure not only in touching the ruby, but also in the power of directing efforts with precision. This is the basis of the strength of secondary motives which may in the end override the primary motive for which they were formed.

We see this in the more developed state when a student, finding that he must keep in good health in order to work well, plays cricket. He may take such pleasure in his expertness in the game that he neglects his studies altogether. Or a surgeon after trying to kill his enemy in a duel may, if called upon, exercise a high degree of skill in saving his life.

We referred to the child's desire to touch the ruby. What is desire?

Desire is not merely the powerful representation of a pleasurable condition. The exercise of any faculty, within due limits, normally brings pleasure; but the lack of exercise brings at length a vague sense, not of pain but of unrest.

Again we have seen that the child's touch on the live coal produced a storm, which, though it resulted in appropriate directive efforts, in this case away from the source of sensation, yet extended far beyond the scope of these efforts.

Now the deepest desires of our nature have reference to the preservation of life, and in their most intense forms they do not attract us by a pleasurable representation, associated with purposive actions; they reverberate throughout the whole organism, and the actions which they stimulate are often beyond the control of the Will.

Thus the thirsty seaman on the raft requires all his strength of Will to resist the temptation to drink the sea water, even though, if he give way, his actions are appropriately directed. If it were sought to prevent him he might even show cunning and force in effecting his purpose. We could not withhold the word Will from such a case.

We have here two opposing forces: one prevails; a resultant of the whole organism is formed accordingly (cf. pp. 336, 373, 582, 587).

There may be cases where a strong man hesitates as to which of two opposite courses to pursue. Having decided, he puts the whole strength of his nature into that which he has selected. Thus a captain may have made a sortie from a besieged town. He finds the enemy in strength before him. He retires, but finds his route to the town intercepted. He may hesitate whether to return, or force a passage through the ranks of the enemy he first encountered. In either case he may show strength of Will.

A man may hesitate whether to give way to the promptings of a personal ambition lower than the ideals for which he had hitherto fought, as Napoleon after Lodi. But in carrying out his designs he may, in an extraordinary degree, exercise Will.

Let us consider one or two examples where desire is less imperious than in vital matters but still strong.

A soldier on the battlefield has lost his way. He

believes that he has come to the place where he left his horse but that the horse has disappeared. He thinks he will soon be taken prisoner. He has a desire for a horse, but there is no strength in his desire, for he does not think the realisation possible. Suddenly in rounding a corner he finds that he was out of his bearings. He recognises his locality. He sees his horse, and the desire to regain possession of it becomes intense. He exerts every energy to that end.

Here desire is increased in proportion as Will is exercised in a definite way likely to lead to fulfilment of the desire. This will be found to be always the case.

We see in this example also that Will is strengthened by the exercise of purposive acts.

In the discussion on Externality we found that the object was recognised as external partly by means of the conception of the efforts necessary to reach it. It is this clear conception which helps to give it the impression of reality. Similarly the clear conception of the necessary efforts to fulfil a desire give it greater energy and help towards the impression of reality.

For example, a traveller in the desert has often been deceived by the mirage. He beholds again a smiling oasis of trees and grass and wells of water, but he feels inclined to turn away his head from the vision. But something attracts his attention. He recognises that this is not a mirage, but a reality within his reach. What was previously a brain-sick appreciation of a beautiful image becomes now an ardent desire, and the power of Will is called forth to its utmost scope.

John Alden believes that Priscilla is indifferent to him. Desire becomes a far-off dream. He learns that she loves him, a desire throbs through all his

nerves, and Will enables him to dare what he had not before thought possible.

Desire is, we find, related to Presentation associated with emotions of pleasure, and with Will. In some forms its relation to pleasure is rather that of the uneasiness produced by the feeling of deprivation of something whose normal exercise gives pleasure. In this case the whole scope of the Impulses associated with it may be so great and their display so uncontrolled that Will is not conspicuous. Its most characteristic manifestation is when the pleasurable feelings are vividly represented and appear as realisable, while Will is exercised with energy.

It may be objected that all pleasurable feelings are associated with some desire of realisation, and that desire is therefore nothing more than the sentiment of pleasure; but though weak desires may in cases verging on indifference be merged in a mere sentiment of pleasure, and though even æsthetic pleasures may have a faint association with Will, yet the difference is in general marked. Thus we may speak of desire and pleasure as distinct, as we speak of animals and vegetables as distinct, though there are borderlands where one merges into the other.

We have arrived, from the basis of the study of the child, at a conception of the Ego built up by complex factors; and we have found in analysis various conditions that contribute to the expression of Will.

But these two conceptions must now be considered in more intimate Association.

The individual forms a representation of the Ego, which is not only associated with his previous experience and his present experience, but with all manner of possibilities, many of them unrealisable, but

all connected with the main directive opinions or ideals of his life.

At every experience also, such as we have observed, in the training of the Will, the Will is definitely associated with the Ego so represented.

Thus there grows up a body of co-ordinated ideas which form an authoritative association derived not from the influences of others (cf. pp. 357, 365, and 503), but from the whole strength of the individual's own directives in life.

This then must always be considered in addition to the other factors already discussed (cf. pp. 587 *et seq.*) when a resultant is sought in regard to any condition with which the mind has to deal.

An example of the strength of this factor is found in the story of Alexander the Great and his friend, who in face of great difficulties said: "If I were Alexander, I would go back"; to which the conqueror replied: "So would I, if I were Parmenion."

An example of this authoritative association arising from within and overriding a contrary expression of Will, occurs in the life of Napoleon, when, seeing nothing before him but abdication and disgrace, he resolved to commit suicide. After he had swallowed the poison his conception of his whole character and career rose before him, and he took the antidote.

An example of authoritative association arising from without and overriding a strongly formed Will is found in the meeting of Napoleon and Ney during the march to Paris after the evasion from Elba. Ney had sworn to bring Napoleon back to Paris in an iron cage, but the sight of the former leader and the tone of his words overcame this resolution. He returned to Paris with Napoleon to drive out the Bourbons.

Vanity, which is not altogether a bad quality, contains

factors both of subjective and objective authoritative association.

Bonaparte's manifesto to his soldiers, "From yonder pyramids forty generations look down upon your actions," formed a strong incentive to Will. It was an example of authoritative association having a strong subjective appeal.

Nelson's signal at Trafalgar was based on authoritative association ostensibly more objective in character: "England expects that every man will do his duty."

Cæsar's exhortation to his men at Pharsalia when he directed them to strike at the faces of Pompey's patricians was rather an address to the habit of legionaries inured to war and prone to victory.

Yet looked at closely there is not a great difference either in the manner of operation of these various exhortations or in the emotions which they stirred.

The soldiers of Bonaparte and the sailors of Nelson had equally with Cæsar's troops formed the habit of tough fighting. A great part of the stimulus in each case was the desire to obtain their commander's approbation.

§ V. Freedom of Will

A further question may be asked concerning the freedom of the Will. This is, however, a matter of controversy in another domain. In as far as we have dealt with it, we see that the Common Sense philosopher may declare that he knows by his direct experience that the Will is free. But, as we have observed in discussing externality, we cannot always place reliance on the declarations of Common Sense, and we may suspect from the previous example that further examination will reveal to us that the matter is not quite so simple as Common Sense would have it.

The freedom of the Will presupposes the Ego and the Will.

Therefore the matter is not to be settled by any Immediate Presentation, for we have seen, in our analysis, by what complex forms these conceptions are determined.

Having arrived at a conception of the Ego, and having familiarised ourselves with that conception, which we may assume to be fairly constant within short intervals of time, we find the Ego considering two courses and choosing after that consideration.

Even the exponent of Determinism who here opposes the doctrine of the Common Sense school would grant so much. He sees, in the complex of the Universe, a certain circumscribed complex, the Ego, and he sees that the Ego must be an important factor in producing a resultant of certain forces that impinge on it. And as the Ego has also consciousness of the direction so given to those forces, it is only a question of language for the Determinist to acknowledge that the Ego has free Will within the scope that we have considered.

But not even the Common Sense philosopher would hold that the choice was formed without grounds. When we make the examination of these grounds to discover wherein they consist we are carried also through the whole analysis of the Ego and of the Will, and we find that this analysis rests, in as far as mental operations are concerned, on the Fundamental Processes we have set forth. These Processes, we have also seen, rest on something beyond our consciousness. Given the conditions of their exercise, they are inevitable.

In the universal arrangement of things, that only occasionally impinge on our consciousness, is there a definite purpose of which our own efforts and dispositions form part?

Shall we ever, or do we betimes even now, have consciousness also of this purpose?

In the arrangement of things that determine our Will, is it possible or is it true that we are endowed with something—freedom of Will—that escapes the inevitable character of that arrangement?

These are questions with which our present inquiry has no further concern than to indicate in what way we may be led to them.

§ VI. Summary of Discussion of Ego and Will

The Ego and Will may be considered by means of a study treated synthetically, viz. that of a child forming rudimentary experiences.

The child may make considerable advances in experience without having a conception of the Ego as a Unit. It is only by accumulated experiences that the child attains a conception of the Ego.

No one ever attains a full knowledge of the complex, afterwards referred to as the Ego, either with regard to its physical basis or the possibilities of combinations of its faculties.

The aphorism of Descartes, "Cogito, ergo sum," cannot be taken as the basis of a proper treatment of psychology; it assumes what it desires to prove, and the position expressed is already of great complexity.

The conception of the Ego is aided by the instruction of others; but in this way errors also arise.

The basis of Will is to be found in the Fundamental Process of Impulse. Impulses are associated with the Hedonic principle.

Impulses then become associated between themselves, and they are associated also with ideas and emotions. Hence arise impulsive tendencies of great strength.

Will is not a distinct faculty having a certain relation to the totality of faculties which it governs.

As each idea has its own Memory, each Impulse has its own strength, which is its element of Will.

The Will can be cultivated, but this must be understood with various restrictions comparable to those considered in discussing Memory.

The Impulses arising in experience are the resultant of those experiences, the previous experiences, and the whole original constitution, with its physical basis, which has been produced by evolution through countless generations of experience.

The strength of Impulses which form Will depend on the general vigour of the constitution and the temperament of the individual.

There is always found Impulse towards the continuance or increase, within certain scope, of pleasurable conditions of the mind, sensations, or emotions.

There is always found Impulse towards overcoming resistance and enduring pain, and this is also associated with the Hedonic principle.

Desire may be considered as related to pleasure and to effort.

The relation of desire to pleasure depends on vivid representation of pleasurable conditions or vivid realisation of conditions of unrest produced by the lack of normal exercise of faculties.

The relation of desire to effort may be that it causes involuntary effort; but associated with this also is strong voluntary effort.

In connection with voluntary effort associated with desire, we speak of Will.

Will reaches high expression when purposively directed by strong desire within possibilities of realisation.

The exercise of faculties directed purposively by Will produces skill, and, when the combinations become elaborate, secondary motives are formed which may become stronger than the primary motives which called them into existence.

Constant exercise directed by Will produces habit which tends to become automatic, and which may become stronger than a special operation of Will called into exercise on any occasion.

As the conception of the Ego becomes formed, the Will is associated with it, and it is this combination which gives peculiar characteristics to the Will. Will is not only referred to the Ego with all present experiences, and with the record of experiences, but also by virtue of the representations of the Ego, particularly in regard to its dominating principles. This combination with certain qualities of temperament is a factor of pride. Hence there arise powerful authoritative associations of subjective origin, tending to strengthen the Will in the direction involved.

Will is also influenced, sometimes powerfully, by authoritative associations arising from others, in what may be called an objective way. The symbols by which these operate are obedience, and, in some circumstances, duty.

Combinations of various authoritative associations acting upon certain qualities of temperament tend to form vanity, which is often a powerful factor in Will.

In cases where strong exercise of Will is demanded, there are also the factors of the vivid representations of pains following upon failure, and the rewards of success. These factors may be considered in various ways, and they may be all factors in certain cases.

To these may be added unknown causes that lie beyond the bounds of our consciousness. For as,

when the conditions are given, all the Fundamental Processes follow spontaneously, and as these are all associated with the Hedonic principle, it may be that some purpose to which they are directed may be expressed also in some directive manner in the larger combinations of our Impulses, emotions, temperament, and that this expression may have its force in Will.

Freedom of the Will is apparent if we content ourselves with superficial observation within a restricted scope.

On analysis it becomes clear that since all the various factors of the complex Will are determined by something that lies beyond our control, then Will itself is determined.

But here, too, we may at least propose questions as to some purposive arrangement which has produced these factors; and questions also as to the possibility of a freedom of Will that escapes this inevitable determination.

CHAPTER IV

DREAMS

In the previous investigations we have seen how ideas are associated, and also, in the chapter on Association, we have learnt that ideas, emotions, desires, and any combinations of these forming a complex system may be associated.

Memory produces ideas that are associated with other ideas, or that arise through stimulation of any part of the brain. We have already considered the conditions under which Memory acts to the best advantage.

We have also seen that these stimulations of the brain may be independent of the organs of sense by which impressions have originally arrived. A certain element of the brain having been stimulated in a certain manner, an idea arises accordingly.

We may further say that in similar circumstances an idea corresponds to the stimulation of a definite element of the brain, for this assumption rests on as stable a base as that of the constancy of the physical system within restricted limits of time and place (cf. pp. 74, 77, also 81).

Obviously, also, when the brain receives a stimulation related to vision, the mind knows nothing, by this source, of the eye.

Therefore, independently of the conditions under which Presentations originally occurred, we may take

them as referred definitely to the physical correlative; that is to say, we may take it that when a certain part of the brain is stimulated in such a manner as to reproduce fairly well the conditions of its original stimulation, ideas will arise fairly closely resembling the origina ideas.

We are only imperfectly acquainted with the mechan ism of the senses. What are the exact conditions o stimulation in the brain we do not know. But we observe that stimulation depends on the blood supply, for hyperæmia of the brain produces an excited condition of the ideas, and anæmia, if carried to a certain degree, causes a loss of consciousness.[1]

When we lie down to sleep we close the eyes, and so shut off one source of stimulation. Whether we can close the ears is a question that has not been discussed. It will be observed, however, that the stapedius muscle is attached to the stapes, the last of the ossicles of the middle ear, and that its action is to tilt the stapes backwards. Its function is said to be unknown, but it is possible that it serves some purposes of throwing the hearing apparatus out of gear. In any case we know that in sleep the mind is less susceptible to receive sensations of hearing, and it is possible that the brain receives less stimulation.[2] The

[1] Curiously enough, Albrecht von Haller, who was the pioneer of the scientific study of the subject, believed that venous congestion prevailed in sleep. In 1795 Blumenbach had an opportunity of observation in the case of a young man with fractured skull, and he found anæmia of the brain in sleep. In 1854 Donders experimentally determined the fact. The work of Durham and Hammond, from 1860 to 1869, confirmed these conclusions. Howell, Mosso, Hill, 1896–1898, studied the question of blood pressure. Hughlings Jackson in 1863 had observed the retina during sleep with results thus subsequently confirmed.

[2] E. Trumbull Ladd has written on visual dreams. Jastrow found the dreams of the blind relatively deficient in visual impressions. Wundt ascertained that hallucinations of taste and smell seldom occur in dreams. Mary Whiton Calkins found two cases of sensations of taste in 335 dreams. Titchener experimented, with like results. A. Monroe has also studied taste dreams. The results are in accord with what is here stated.

sense of touch and that of taste are also kept quiescent; and the sense of smell may be at least removed from any unusual source of stimulation.[1]

The impressions derived from nerves subserving great physiological purposes are also kept as free from excitement as possible. Thus hunger is avoided by taking a meal some time before lying down.

The processes of digestion should in a healthy person give no prominent indication in consciousness. The muscles are rested, the muscular sense is kept in abeyance.

The action of the heart is controlled by entertaining quiet ideas as much as possible, but moderate fatigue aids the purpose of controlling the heart's beats so that too much blood is not sent to the brain.

Under these conditions sleep is often dreamless. Dreaming occurs when any part of the brain is stimulated beyond a certain degree. The ideas that arise in sequence will correspond to the stimulated area, but it does not follow that the sequence will be the

[1] The physiology of sleep offers a problem in which no work has been done which is completely satisfying. All the explanations hitherto offered are but tentative and partial. It may happen that some fairly simple theory may yet be reached, but it will require to cover the sequences of a vast number of curious phenomena. Certainly there has been no lack of theories. Recently Legendre and Piéron have put forward a theory of auto-intoxication producing sleep. What is new in this theory is that of the imputed faculty of cells in the frontal lobe to produce an antitoxin which neutralises the poisons formed by the exertions of waking life. Hence too arises the suggestion of treatment by a serum. A theory of auto-intoxication was put forward by Obersteiner in 1872, and his work was followed by that of Preyer and Rachel. Selmi, in 1870, had worked at the theory of ptomaines. Brieger and Errera continued the work. A more general consideration of the chemical conditions of sleep was that of Pettenkoffer and Voit in 1867; while Wurtz, in 1894, has written of the chemistry of sleep. The histological aspect of the matter soon leads to the realm of pure cytology, adorned by such names as those of Ramon y Cajal, Lugaro, and Demoor. The question has been studied from the standpoint of evolution by Hodge and Aikins, and Sergi: psychophysically by Külpe: "Outlines of Psychology" (Trans. 1895). A number of observers have investigated the subject by the medium of hypnotism. Amongst the most interesting is Marie de Manacéine (1897).

same as in the original case. We have already seen in discussing Memory that Association may be stronger between certain ideas that have not occurred in sequence than with those in sequence.

Thus in dreaming there is a liability to form Associations between ideas, perhaps quite incongruous, of occurrences that have struck the attention forcibly about the same time. Hence arise the fantasies of dreams. Moreover, as in our waking hours Associations may be formed between one set of ideas and another set arising in quite a different way and perhaps overriding the first (cf. pp. 541, 573); so it may happen that in dreams Associations may arise between ideas corresponding to a certain area and those corresponding to a widely separated area, stimulated possibly by virtue of the physiological processes of the body which are in exercise, or by some abnormal disturbance which affects the brain.

An amusing instance of this, where stimulation arose from without but not with sufficient energy to wake the sleeper, is that told by Captain Mayne Reid, the writer of delightful stories of adventure, who dreamt one night that he was scalped. On awakening he found that he had a boil on the head.[1]

This illustrates in what way incongruities may arise, for the stimulation may be real though connected with internal organs, and consequently not so obvious as an irritation of the scalp.

We find here, however, no great difference between the combinations of ideas in dreams and in the ordinary condition; for we habitually proceed by tentatives formed by Association. But when awake the mind is

[1] In a series of investigations at Wellesley College, Massachusetts, U.S.A., Miss Grace A. Andrews found that 90 out of 118 dreams were suggested by experiences of waking. Ph. Tissié ("Les Rêves," 1890) is in general accord.

more active, the ideas arise from more sources, there is a fuller and readier comprehension of their relations, and those that are incongruous are rejected before they are fully developed.

But the main difference between dreaming and ordinary thinking consists in the possibility, in the case of thinking, of referring to the present reality as a standard (cf. p. 572).

In a limited case, this might be studied, as when a deaf man tries to sing. He produces inharmonious sounds, because he has not, like the normal man, the opportunity of comparing the result of his efforts with the notes he wishes to sound.

In reality, if a person imagined a rabbit looking at his watch, as in the case of Alice in Wonderland, any of the objects which struck his attention in looking about him would in connection with that representation bring ideas in Association that would show its absurdity. Or even if the individual did not look about, the general activity of the brain we have spoken of would be sufficient, for relatively the image of the rabbit would be less vivid, and it would be associated with a number of other ideas inconsistent with the possession of a watch, and moreover the origin of the image would be known in recollection.

If the question be put as to whether a certain occurrence in the past were a dream or a part of a real experience, the test might be applied to form ideas in Association which would make a continuous series up to the actual experience of the present time. If the ideas were due to a dream, it would not be possible to form such a series: if to reality, then it would be possible.

A story is told of a Chinese philosopher who dreamt that he was a butterfly. When he awoke, he could

never be sure whether he was a man who had dreamt he was a butterfly; or whether he really was a butterfly who was dreaming that he was a man.

In this case he could not apply the test of forming a series leading up to the present reality, for it was this presumed reality that he suspected might be a dream.

The only help one could give him would be to ask him to observe the liveliness and multitude of his impressions, the general consistency of these impressions, together with a long range of recollections in which he had comported himself not like a butterfly but as a man.

There are, however, all sorts of inexplicable incongruities in life. The impressions of some individuals are not very lively in reality, and the dreams of others may be vivid. Many of the profoundest philosophers have likened our life to a dream. Poe calls it a dream within a dream. Others, as Tolstoi did, believe that it has somewhat the same relation to an underlying reality as dreams have to life. Therefore the test recommended to the Chinese philosopher has no absolute sanction; but neither, so we have found, has any result of our Reason (cf. p. 337).

There is no sharp definition between dreaming and thinking. It is possible in dreams to know that one is dreaming.[1] This may occur if a certain dream of a striking character be often repeated. The mind on waking associates that set of ideas with dreaming and applies the symbol, and this symbol, dreaming, may arise in the dream itself.

A man who has committed a murder may reveal

[1] For this, stated from my own experience, I find confirmation by H. Beaunis in an article, "Contribution à la Psychologie du Rêve"; and by James Ralph Jewell, "Psychology of Dreams."

it in his sleep, for during his ordinary life he has an insurmountable tendency to "work over his crime," but the expression of this is prevented by the exercise of Will.

In dreaming, the Will in respect to these ideas lacks the stimulus of realities, and the process of thinking continues fairly well on the same lines as during wakefulness.

Certain of the most intense processes of thought are not greatly distinguishable from dreaming—viz. those that produce the utmost concentration of mind.

It must be remembered that the working out of a complex problem is effected by reducing it by analysis to the consideration of simpler problems in sequence. At a certain time therefore the working of the problem consists of tentative efforts to find a solution of a well-defined subsidiary problem. And so it may happen that any one accustomed to mathematics may work out problems in Integral Calculus, for example, while walking along the street (cf. pp. 413, 415).

Concentration of mind is aided by constant practice in a certain set of ideas, so that the symbols and processes become familiar; by great interest in the subject; by exercise of Will in holding the problem before the mind; by habit; and by the absence of excitement or solicitation from without.

This absence of distracting stimulations may be due to various causes, one being the performance of some habitual and monotonous function of daily life which has become almost automatic, such as walking along a familiar path.

Hence absent-mindedness occurs often when the brain is most busily occupied with the highest kind of intellectual work, as in the case of Ampère, who, walking on the Pont Neuf, threw his watch into the

Seine and put a stone which he had been looking at into his pocket.

Moreover, even in the problems involving in their full scope the greatest diversity of knowledge, it will be observed, in accordance with what has been said, that only a limited area of the brain is excited at one time.

Now if we compare such a condition with that of dreaming, we find in both an absence of external stimulation and a tracing out of the ideas in a restricted part of the brain, but in association with ideas arising, in a manner which we may call subjective, from some other area.

The shock of surprise when one is recalled from such a condition of mind to the present realities is sometimes more startling and painful than being waked from sleep. Swift, who had no great respect for science, ridiculed learned men in "Gulliver's Travels" as the struldbrugs who had to be waked up now and then by being struck on the ears with little balloons.

The condition of great concentration of thought, moreover, may pass into that of dreaming. Froude said that he often used to put himself to sleep by speculating on Kant's question as to whether we remember a previous life.

✓ The principal differences between dreaming and absorbed thinking are that in the case of thinking the individual is generally up and dressed, and is consequently not overcome by fatigue; that the thoughts are carried on with greater energy; and that the Will is exercised by habit and by the stimulation of ideas in association with some image or representation; and that moreover the mind details off a small part of its energy to watch present realities.

But at times this office may become neglected. The

force of Will may persist in regard to a set of ideas even in dreaming, for both the image persists and the faculty produced by habit. We have, then, only left the general physical condition and the energy of the ideas.

But suppose that the mind has been for some days incessantly occupied with a puzzling problem which has disturbed the rest. Then suppose that after fruitless endeavours to find a solution the individual throws himself on his bed and falls to sleep, but that his sleep is excited and disturbed, and that dreams on that subject intervene. The dreams are hardly if at all distinct from the thinking of his wakeful hours.

Hence we find explanation of the well-authenticated stories, principally of mathematicians and musicians, that work has been accomplished in dreams that has baffled them while awake.[1] In such a case it will be noted the mathematician goes to his desk and writes. These are acts that are inconsistent with true dreaming, for they depend on impressions from without; on a recognition of the due proportions of things; and on Will exercised in accordance with this impression. The state is something intermediate between dreaming and the ordinary normal condition, but to the intense previous concentration and excitement over recondite things a similar description might be applied.[2]

[1] Lombroso relates many instances of Goethe, Klopstock, Voltaire. Sardini composed in sleep a theory on the flageolet. Newton and Cardan resolved mathematical problems in dreams. Condillac completed during sleep a lesson interrupted during waking hours. La Fontaine composed his "Two Pigeons" during sleep. Dr. Chabaneix adds instances drawn from the lives of Heine, Schopenhauer, Wagner, and Tolstoi. Coleridge, composing "Kubla Khan" in an opium dream, is not quite in point. Alfred de Musset found the inspiration of some of his best poems while in a state of intoxication from a mixture of absinthe and beer. On the general subject of the continuance of waking and dreaming states, J. M. Guardin, Sante de Sanctis, Paulhan, and E. Boirac have written, with views in accord with those here indicated.

[2] In a lecture on Sleep John Hunter said: "It is even possible to dream when awake; it is only necessary for the thinking power to take possession

Dreams are often very short in duration. It has occurred to me twice to be able to measure the duration of dreams. On one occasion I heard the first stroke of a clock striking nine. I did not hear the second stroke, I heard the last. In the interval I had dreamt a long dream.[1]

Addison told a story in one of the earlier numbers of the *Spectator* to illustrate the doctrine of Malebranche and Locke as to relativity of time. An unbelieving Sultan had ridiculed a passage of the Koran, which records how the Angel Gabriel, having taken Mahomet out of his bed one morning, showed him Hell, conducted him through the seven heavens of Paradise, enabled him to hold ninety thousand conferences with God, and brought him back to his bed before the bed

of the mind, and proceed with an action with which the present sensation has nothing to do. Now, whenever the body loses consciousness of its own existence, it may be called a waking dream, and this is often the case when people are in deep thought."

Stevenson's Jekyll and Hyde dream may also be cited in point.

Professor Hilprecht of the University of Pennsylvania relates an interesting experience which occurred in 1893, while he was engaged in studying objects excavated at Babylon. Two drawings represented fragments of agate, inscribed with characters. They were supposed to be bits of finger-rings, and, being of different colours, were not closely associated together by the professor. But in a dream he saw an Assyrian priest, who told him how the priests of the temple of Bel, having received a votive cylinder of agate from their king, were ordered to make agate ear-rings for their god. They made three by cutting up the cylinder, and the professor would find by fitting the fragments together that these were two of them. He did this, and found that they gave a continuous inscription.

[1] Baldwin ("Feeling and Will," 1891) was able to measure a dream by the beating of a clock. Mumford ("Waking, Sleeping, and Dreaming," 1893) relates a striking case when the pulling of a bell set a dream going, and so enabled a measure to be taken. H. Spitta found two minutes enough for a long dream. Clavière (*Rev. Phil.* 1898) gives a case where a dream could not have lasted more than 22 seconds.

The philosopher and physiologist Claparède experimented by allowing drops from a phial to fall upon his head at regular intervals. The dream that resulted might be rapidly indicated thus: (1) He committed a murder in Paris; (2) fled to London; (3) took ship; (4) arrived in New York; (5) fled from police; (6) to Chicago; (7) found himself tracked; (8) escaped to San Francisco; (9) embarked to Japan as supercargo; (10) sentenced to death at Yokohama; woke.

was cold, and before the pitcher which had been overturned as the Angel was carrying him away was emptied.

A doctor in the law, who had the gift of working miracles, undertook to convince the doubter.

The story relates how the Sultan was cast into a dream, which was very circumstantial, and that when he awoke he found that he had not stirred from the place where he had known himself to be standing immediately before.

These stories of the shortness of dreams, however, do not prove the relativity of time at all; they illustrate rather one aspect of Association, and they prove the power of symbolisation.

Time is as essentially an incident of sensation as kind and intensity, and this is seen not only in its effects in consciousness but also in its effects on the marvellously complex system whose resultant determines thought at any instant.

Hence if the idea be similar in all respects to a sensation except that of time, the reproduction does not correspond to the original. But if this be true for a single sensation, it is true also for emotions, and for all combinations of these.

We will see the matter more clearly if we recognise that the problem is not peculiar to sleep. It has been often said that persons just saved from drowning have beheld their whole life pass in series before them. A similar experience has been related by a man who was hanged, but cut down in time to save his life.

A lecturer, if he have a vivid style, and if his lecture be well illustrated, may conduct us in an hour through a thousand years of the history of a foreign country; but the sum total of the length of the time elements of all our mental impressions is but an hour,

We may, by a series of panoramas, as, for instance, those gigantic and impressive representations of Poilpot, obtain a vivid idea of the day's life of a city such as Rome; but the Memory of it is far less vivid than that which would arise if we had spent a day in Rome.

We have seen that the most complex set of objects may be regarded as a Unit, and we have seen that though the mind has consciousness of only one Unit at a given instant, yet such Units may succeed with great rapidity. Further, the complex of a Unit reproduced in Memory may afterwards be analysed in detail. This process is wonderfully aided by symbolisation.

And we have also seen that ideas in association are not necessarily such as correspond with original sequences, but are influenced perhaps by some striking relation which bridges over any series of sequences.

Herein, and not in the relativity of time, we find the explanation of dreams, short in duration, covering apparently long periods. The mind proceeds by Association to Association, finding at each instant the most impressive stamp of the Unit, and by the process of Memory and the process of symbolisation we find that we may elaborate the series in terms of time elements that did not occur in the original representation.[1]

The interpretation of dreams has played a great part in the history of the world. It has been raised to the same pinnacle of reverence as the sacred sciences of inspecting the entrails of fowls or casting horoscopes.

Nowadays it has been unduly despised. Even in a superficial view of dreams they may have great significance, as revealing some secret obsession, or some underlying motive, or factor of character of the dreamer.

[1] Besides those already cited, Victor Egger, de Lorrain, Hildebrandt, P. Schwartzkopff, and R. S. Woodworth ("The Rapidity of Dreams," *Ps. Rev.* 1897) have written in general agreement with the positions here set forth.

But with deeper research into their physiological and psychical causes, they may be seen to have great significance. From the character of the dream the area of the brain excited may be inferred, and the question must then be raised as to the cause of this local hyperæmia.

Dreams may thus point to heart disease, to some general or local instability of nerves, to adenoids, or possibly to some digestive troubles. A few medical workers have already commenced investigation on these lines, and their study is likely to be both highly interesting and of considerable practical value.[1]

[1] See, for example, "La Psychologie du Rêve," by N. Vaschide and H. Piéron. Of those who have written especially on the modern interpretation of dreams may be also mentioned Havelock Ellis, Horace Hutchinson, P. Graffunder, Hildebrandt, and B. Onuf.

The literature of the subject is extending considerably of late years, particularly in France and in America. In addition to those already referred to, the following may be cited: L. Dugas, "La Psychologie du Rêve"; James Sully, "The Law of Dream Fancy," 1897; F. Scholz, "Sleep and Dreams" (Trans. 1893); J. Delbœuf, "Le Sommeil et les Rêves"; E. Goblot, "Le Souvenir des Rêves"; Max Geissler, "Aus den Tiefen des Traumleben"; E. Maillard, "Etude sur le Sommeil"; A. Fernand, "Le Sommeil et le Rêve"; Maury, "Sommeils et Rêves"; D. (L.), "Apropos de l'Appréciation du Temps dans les Rêves"; John Bigelow, "Mystery of Sleep"; T. Crichton Browne, "Dreamy Mental States." The question has been studied by the statistical method by F. Heerwagen, J. A. Jewell, and Julia A. Gulliver amongst others. Henry Hubbard Foster has written interestingly on "The Necessity for a New Standpoint in Sleep Theories" (*Am. Jour. of Psych.* 1901). The references in standard works of general psychology are too numerous to admit of mention.

CHAPTER V

PHYSIOLOGY AND PSYCHOLOGY

PART I

PRELIMINARY DISCUSSION

§ I. PHYSICAL CONDITIONS

THE observation of the dependence of thought on the physical conditions of the individual has led to a great variety of special studies of physiology in its relations to psychology. Much of the work done in this respect has been of great interest in itself, but it should be set forth at the very threshold of the subject that there is a limit beyond which observations in physiology cannot carry us.

There is an entire domain of Psychology which has no more necessary connection with physiology than has the science of mathematics. Certain physiologists, it is true, speak as if thought were a kind of nervous reaction of the brain. But confused notions of this sort tend rather to enforce what has just been said, for physiologists who so speak are ignorant of the elements of Psychology. Their system is based on a fundamental misconception of the nature of sensations or ideas[1] (cf. pp. 79, 502, 558).

The peculiar problems of Psychology demand pro-

[1] Moleschott and Büchner concluded that thought must be of a material nature because it took time.

cesses of investigation, of analysis, of introspection to which physiology can give no other assistance than vague general suggestions, and, occasionally, the basis of graphic metaphors. It is true that certain physical phenomena seem to be invariably antecedent to thought, but we cannot form the nexus between these physical phenomena and thought.

Even with regard to the physical instrument it involves a certain strain of language to speak of the brain as necessarily the most important part, for between essentials it does not seem possible to find degrees of comparison.

The external organs of sense are necessary to the operations of the brain. The stimulation of these organs of sense is itself a work of great complexity. The brain can certainly form an image of an object not directly represented in the retina, but an original stimulation of the retina was necessary to produce this condition.

But if the knowledge of the topography and histology of the brain were immeasurably more advanced than it now is, or even can hope to be; if, in fact, during the processes of thought we could see with microscopic eyes the actual character of nervous stimulations, and the changes in nerve filaments and nerve cells; if we could observe the molecular arrangement itself of the whole vast network of nerve fibres and nerve cells of which the brain is essentially formed; we should be advanced not one jot in the matter of certain Presentations, such as sensations, which can only be known to us as Immediate in their own quality.

But in spite of manifold research, the study of the brain is far from having attained even its possibilities. That is evident especially to those who have worked

in this matter, for they know more clearly than others the difficulties in the way.

The most direct method of examination is that adopted by Schiff with good results. He made a series of sections of the brain taken at regular small distances apart. These he examined under the microscope, so as to discover, and mark step by step in the successive sections, the position occupied by the minute area representing any particular strand or nerve fibre in that section.

The effectiveness of this method, however, is limited by various conditions.

The brain must be hardened for about three weeks before the sections can be obtained, and the process of hardening must to a certain extent warp the strands of which it is composed. Then the sections must be stained so that the different areas corresponding to the supporting structure, neuroglia, for instance, and nerve fibre may be distinguished. This is but a crude method of examination, though the best known at present. Then there are various limitations of the microscope itself.

Other methods of research which supplement that of Schiff may be stated. Degeneracy of brain tissues is often shown by well-marked physical and mental consequences during the life of the patient. If the brain of such a patient be examined after death, it is sometimes possible to find in the sections the areas affected by the degeneration. A correspondence is assumed between the observed physical and mental signs and symptoms and the state of the brain.

A detriment to work of this kind is that the mental processes themselves, on the purely psychological side, have not hitherto been analysed with sufficient illumination; consequently, a good classification of mental symptoms has not been forthcoming.

Another method of the study of the brain has its

starting-point in the observation of injuries, either to the brain or to the spinal cord, combined with observations of the resulting physical signs or symptoms, and the result of the post-mortem examination in regard to changes in brain tissues.

A more exact method consists in substituting for accidental injuries experimental wounds designed in view of the solution of certain problems. Another method is that of directly stimulating certain brain centres and observing the effects.[1]

Broad, general, but very valuable guidance is obtained by the study of the development of the individual; by the study of the development of the brain in different individuals of the same species; by the study of comparative anatomy with special reference to brain structure.[2]

These methods are all too coarse to be satisfactory. For example, it is not possible to detect the lesions corresponding to well-marked hysteria which may produce excited physical displays and veritable storms in the world of ideas.

Physicians have been accustomed to make a distinction between diseases producing changes in the organism and "functional" diseases, among which is classed hysteria. Then again a great many diseases used to be considered as having an "idiopathic" origin, that is to say, the diseases were supposed to arise for no defined reason.

[1] Flourens in France and Horsley in England are notable names in this regard; the total literature is, however, immense. Recently I have read of elaborate experiments on monkeys conducted at the Government Hospital for the Insane at Washington, U.S.A. Dr. W. T. Shepherd has also carried out at the George Washington University a series of experiments on monkeys, and has demonstrated, for example, the colour sense in these animals. The results of these investigators will be found clearly capable of interpretation in accordance with the present analysis.

[2] Flechsig is the most remarkable name in this branch of science.

Increasing knowledge has reduced the number of idiopathic diseases, and unless we are prepared to assume that effects arise without causes, we may conclude that the only reason why hysteria is considered a functional disease is that our methods of investigations are too coarse to enable us to distinguish the corresponding lesions, or morbid state, of the brain.

Even in such grave disorders as epilepsy and lunacy it is often impossible to find any distinct cerebral lesion or degeneration.

To hope to obtain then, in such circumstances, any direct information as to mental processes would be as absurd as if one were to look down on London with a telescope in order to guess at the secret of a Cabinet meeting. When we extend our inquiries we find that beyond certain indications we know nothing of the real structure or mode of operation of the end-organs serving the senses. Our knowledge is sufficient only to form the foundations for various hypotheses, of which some must be false, and of which possibly not one is true.

We have already observed that even with such a patent object as the stapedius muscle we are in doubt as to its function.

We do not know what nerves correspond to the sensations of heat, and cold, and pain, and various other sensations and feelings already referred to (cf. p. 69).

The study of localisation in the brain of various centres of sight, and of hearing, is still imperfect. Even at the threshold, where questions arise such as that of the functions of the cerebellum, opinions differ. Sir William Gowers held the theory that the cerebellum acted as a higher controlling centre upon some of the exchanges of the cerebrum.

Certainly in considering the nerves in turn we find that physiology has given us some valuable indications. The course of the optic nerve has been traced with some precision, so much so that from symptoms and physical signs affecting vision we are often enabled to localise the source of the mischief.

The conditions of function of the motor nerves have also been worked out to some satisfactory conclusions. By the study of the paralysis of a muscle, or of a set of muscles, we may discover the seat of a lesion of the brain. The order of occurrence of convulsive movements may afford information as to the character of a hæmorrhage in the region of the fissure of Rolando, where the motor centres are situated.

The fact that the termination of the auditory nerve is found in the organ of Corti proves that this organ is at least an intermediary in the function of hearing, and we may be yet enabled to ascertain its precise action.

The association of the facial with the auditory nerve, and the close neighbourhood of their nuclei in the floor of the fourth ventricle, may be made to account for many phenomena of facial expression connected with emotions derived from hearing.

The association of the vagus nerve, excitation of which slows the heart's action, with nerves to the larynx, its own supply to the larynx, and its function in serving also other internal organs, notably the stomach, and the closeness of its nucleus to that of the facial and fifth: all this indicates the apparatus involved in the expression of deep emotions of grief, as, for example, the heart oppression, the sobs, the convulsed face, the choking voice, the tears. In some very sensitive beings it happens, as recorded more than once in the history of Napoleon, that vomiting also ensues upon sudden violent emotion.

Even the study of the circulating system and the lymphatic system throws a certain light upon the conditions of mental operations, and we see once again from a new standpoint the truth of the aphorism: The whole man thinks (cf. p. 423).

The activity of the brain depends on its nourishment, and its nourishment depends upon a good supply of blood.[1]

We have already seen that inefficient heart action often makes itself known by failure of memory. Calcified arteries or arteries degenerated in the form of arterio-sclerosis show their deterioration in loss of faculty in the parts which they supply.

The faculties of intellect are greatly influenced by the condition of glands which are not usually considered in relation to them. Thus defect of the growth of the thyroid gland results in a condition called myxœdema, of which slowness of the mental operations is one of the symptoms. The thymus gland, of which the functions are less known, appears to control certain factors of development, and so influences the whole temperament of the individual. An overgrowth of adenoids in the upper part of the pharynx is a cause of faulty development which marks the whole constitution, and diminishes mental energy.

The association of the glands with the emotions was noticed by the ancients. At one time they believed that the soul resided in the tonsils. Horace, who was an expert in the matter, seems to have believed that the liver was the seat of the soul of love, if one may judge from a poetical reference.[2] The liver

[1] On the general question it will be interesting to read Hack Tuke, "Illustrations of the Influence of the Mind upon the Body."

[2] At various times and in different countries the soul has been located in the pineal gland, in the ventricles of the brain, in the Aqueduct of Sylvius (Servetus), in the centrum ovale, in the corpus callosum (Willis), in the *nœud*

has more generally been associated with feelings of melancholy. The word "splenetic" indicates the peculiar influence ascribed to the spleen.

The heart, which is a hollow muscle, is now popularly supposed to be the seat of the warm emotions. But the Zulus of South Africa give that place of honour to the muscles of the calf.

Even the veins have been considered to have influence on the mental disposition, for the small salvatella vein in the hand derives its name from the fact that it was held to be the proper vein to bleed for persons of a heavy and melancholy temperament.

The influence of the lungs on the mental operations is evident at once in the fact that vigorous breathing tends to produce energy of the ideas. Tesla, the great electrician, found that his mind worked with greater clearness and force in the pure air of the Western American solitudes.

But a curious fact must be noted of quite another kind. It is remarkable how often phthisis is found associated with brilliancy of intellect. Two of the greatest mathematicians of all time, Abel at the age of twenty-five, and Riemann, died of phthisis. The brilliant English mathematician Clifford died of phthisis. Spinoza died of phthisis. Mozart is said to have died of phthisis. Chopin died of phthisis. Keats, one of the most luminous intellects of all time, died of phthisis. Priestley, the chemist, died of phthisis. Watteau died of phthisis. Sterne died of phthisis.

vital of Flourens, *i.e.* the point of the calamus (Schmidt of Heidelberg, 1887), in the tonsils, in the liver, in the blood, in the breath, in the eye, in the shadow, in birds, in the name, in sex, and, by a priestess of "Soul Freedom" in America, in the left lung. Cf. Hermann Strack, "Das Blut in Glauben und Aberglauben der Menscheit"; and George Henderson, "Survivals in Belief amongst the Celts." Quite otherwise significant is the title of a work of Sirot: "Âme et Cerveau; l'âme existe-t-il scientifiquement?" Finally we have a work by Kostyleff, "Les Substituts de l'Âme dans la Psychologie Moderne."

R. L. Stevenson died of phthisis. Hertz, whose name is immortalised in the Hertzian waves, died of phthisis in early years. Bonaparte, according to the learned researches of Dr. Cabanès, suffered from incipient phthisis during his first astonishing campaign in Italy.[1]

Even gross demonstrations yield data of real use in psychology. Thus the distinction between motor and sensory nerves indicates that the impressions of Effort associated with each should not be confounded.

The recognition of the activity of parts of the brain as the physical correlative of certain aspects of Memory, for example, would appear to demonstrate what otherwise would be difficult of proof, that any Memory may be lost beyond possibility of recovery.

The fact that a man who has had his leg amputated may still think he feels gout in his big toe proves that pains are only referred to the places where they are supposed to exist. Closely considered, this fact aids in the appreciation of the analysis of Externality set forth elsewhere (cf. pp. 543 *et seq.*), and it may be found to have a bearing on the theory of vision. That a tumour in the cerebellum may produce double vision is an important fact with regard to the understanding of the processes of visual sensation and visual co-ordination.

The fact that hæmorrhage in the second convolution of the frontal lobe, Broca's convolution, may be followed

[1] Havelock Ellis contrasts the phthisical and gouty dispositions, for whereas the phthisical are eager, with large conceptions into which they throw themselves feverishly but often ineffectually, the gouty geniuses lay in their work solidly. He cites as examples Milton, Gibbon, Dr. Johnson, Fielding, Congreve, Landor, William Morris, La Rochefoucauld. I believe it is Burton, in his "Anatomy of Melancholy," who gives a terrible list of the ills to which great scholars are liable. Gravel is one. Amongst the sufferers from this complaint may be mentioned Erasmus, Luther, Montaigne, Leibnitz, Bossuet, Buffon, d'Alembert, Rousseau, Voltaire. Those afflicted with calculus may appreciate in a new light the saying of Lombroso, who likens genius to the disease of the oyster that produces the pearl.

by aphasia marks an important step in the history of brain localisation.[1]

§ II. A Note on Phrenology

The study of psychology from the physiological side produced the system of phrenology of Gall and Spurzheim.[2] The abundant absurdities of this theory have been pointed out again and again, and there is no need to refer to them in detail. As an example, Spurzheim fixes on a certain prominence and labels it: Time. But we have seen that Time affects all sensation.

Another prominence is labelled Form, and another in a different situation Constructiveness. But constructiveness cannot be conceived without form. The prominences in the skull do not correspond even approximately to the contour of the brain. Again, all "affective propensities" such as amativeness, or "sentiments" such as wit, are matter of great complexity. Their analysis reveals that they are built up of factors certain of which are common to both.

By combining these factors in all manners we not only obtain the combinations already mentioned but an immense number of others. To label a few of these, which could not be used as elements of new combinations, is not to form a working hypothesis. However, all hypotheses, even the most plausible or the most unlikely, must be judged by the standard of concordance with natural phenomena. In this respect there is nothing to make us suppose that the brain is mapped out in areas corresponding to the ill-classified

[1] The question of Aphasia, however, will be dealt with in detail in a subsequent chapter.

[2] Prochaska (1749-1820) appears to have been the pioneer of this movement.

complexes with which Spurzheim labelled the scalp or the outer aspect of the cranial bones.

Let us consider whether even for the broadest basis phrenology has any ground. The most conspicuous aspects of the head are its size and general shape.

One may hear a phrenologist say: All other things being equal, a big head must be better than a small one.

But that innocently sounding phrase contains the possibilities of many errors. What do we mean by better? If we attempt to render the term more precise we immediately find that the proposition is far from being self-evident. Then, again, it may happen that we are not entitled to say: All other things being equal. For example, the current in an electric circuit depends directly on the electro-motive power, and inversely on the resistance. In such a case we cannot say: All other things being equal a big current is better than a small one. If the electro-motive force and the resistance be equal in two cases, then the currents will be equal; and if one current be bigger than another it implies that all other things are not equal.

We do not say, or at least, not all of us: All other things being equal, the fatter a woman the better. Nor do we say: All other things being equal, a big head has more teeth than a small one. It has not more teeth, and it has not more nerves; nor does it follow that its brain has more nerve paths opened up and co-ordinated.

If a big head has not more teeth than a small one, its teeth, if similarly arranged, will be bigger. Its nerves may also be bigger; and if this proportion were carried all through, the fibres of the entire network of the brain would in the two cases be equal in number.

A small piano has as many notes as a big piano, and it may even produce sweeter music. A small map may have as many details as a big map. And if it be said that there is more room in a big map to insert new details, the answer must be that if the details be in the same relative scales there is just as great a proportion of room in the smaller one.

It may be thought that even if the number of external nerves be the same in a small head as in a big one, yet the number of the paths opened up in the brain network may be different. That is true, but it must not be assumed that more paths are opened up in the big brain.

The nerve strands that enter the brain are conducted in a regular way, and with regular connections through the brain. They form the white matter of the brain. In all normal brains the white matter is distributed according to the same plan. The fibres that form the intercommunications constitute the grey matter.

If, taking the brain processes again as the physical correlatives of thought, we say that for every Association a path in the brain is opened up, then to assume that a big brain has more complex development would be as absurd as to assume that a big man moved his eyes more quickly than a little man, and required less time for an impression to be formed on his retina.

Even in regard to physical strength, in which relations are simpler than in those of the mind, size is not the most important factor. Some of the greatest athletes of the world have been men of medium size. It is a remarkable fact that long-distance runners, who in their feats accordingly furnish an enormous number of foot-pounds per hour, are often small men. At the Marathon race held in London in 1908, Hayes and

Dorando were both small men. Siret, the French champion, is a small man. Shrubb is rather below medium height. Two of the most famous pedestrians of the old days, whose feats have not been surpassed, Howitt, the American Deer, and White, the Gateshead Clipper, were very small men. Short-distance runners, or "sprinters," are often big muscular men, but some of the most celebrated, Seward, Hewitt, Downer, Duffy, and Postle, have been of medium size. Hanlan, the greatest oarsman of all time, was rather below than above medium size. Even some of the most famous pugilists, Belcher, Pearce, Sayers, and Mace, were not big men, although they fought and beat giants. With wrestlers sheer weight is of itself important, but some of the greatest wrestlers have been not very big men of their class, as for instance Clarence Whistler, Hackenschmidt, and Gotch.

But when we consider not feats of strength but feats of deftness of hand requiring a great number of finely adjusted combinations, then size is of no importance whatever. Taglioni, the dancer, was not of great size. Plain and fancy needlework does not require large hands. Great size is not necessary in a painter's hand. And though a conjurer might be aided by large hands, yet the thousand exercises he practises do not notably increase their length or width.

Still less would thinking, which does not correspond to a great output of foot-pounds, be likely to be exhibited clearly in terms of size.[1]

Inferior development of the head is at a certain point inconsistent with great mental development. We are familiar with the microcephalous idiot. But it is also true that idiots with very large heads are frequently met

[1] Sub-microcephaly was found in the cases of Descartes, Foscolo, Tissot, Guido Reni, Hoffmann, and Schumann.

with. An exceptionally large head should always excite suspicion of some malady.[1]

Then, again, while mental activity is represented by the opening of brain paths, yet the character of that activity is of great importance in estimating the quality of a brain and its product. A commercial traveller with a few hobbies, such as playing the violin, rearing bull-dogs, and studying the "form" of racehorses in order to bet, may manifest more mental activity of a kind than a man who improves or builds a dynamo. Consider, as a remarkable example, the prodigious mental energy of Brougham. Few read Brougham now, while the reputation for high intellectuality of Thomas Young increases with time. Yet Brougham's authority, and his ignorance, were both equal to the task of discrediting Young's greatest work.

These examples show that we must also have a standard of intellectual values. Thus on a certain occasion a well-known author, M. Emile Bergerat, who was a candidate for the French Academy, called, according to the etiquette, on M. de Freycinet, one of the most illustrious members of the Academy. M. de Freycinet, who had at that time written only one book, was astonished to hear that M. Bergerat had published over a hundred. But the one volume of M. de Freycinet had a greater influence on the world's civilisation.

Mere mental activity therefore must not be taken as a criterion of brain power. Nor again must popular fame or commercial success.

But these matters greatly obscure proper judgment in considering the real value of the mental output. Taking as the highest type those who are veritable artisans of the world's civilisation, we find that our standard

[1] Quatrefages said that the greatest macrocephaly (large-headedness) was found in lunatics, and the next grade in men of genius.

of good mental activity ought to be energetic thinking along scientific lines; though this again involves a thousand considerations of taste, opportunity, instruction, and certain moral qualities (cf. pp. 381, 390, 398, 409, 412, 421, and 426 *et seq.*).

But having such a standard, we may judge other forms of mental activity comprehensively and intelligently.

One may be struck by the fact that an individual may not find work which allows scope for the development of his powers until after the size of his head has been determined and the sutures closed.[1] But if the size of the head were taken as an indication of intelligence, a man would be classed in the same category whether he allowed his brain to remain inert or cultivated it so as to produce good work in science.

This point will be referred to afterwards.

The question of length of life is also of importance. Our time here is so fleeting in comparison with what we may have hoped to do, or even have attempted to do, that no one becomes well educated even in his special subjects. We have seen that for the proper understanding even of special subjects a vast range of science is required. But we judge not by the standard of a good comprehension of the subjects we study, but by a comparison with others who have also done work in the subjects. Hence even the most active-minded and inquiring man does not develop more than a small portion of the faculties whose capabilities lie within him. So that, again, to judge mental power by mere size of

[1] An important note of H. H. Donaldson (*Journ of Comp. Neurol.*, 1899), who calls attention to the small total volume of the nerve-cell bodies in the cerebral cortex in man. The total weight is less than 27 grammes, therefore less than half the range of variation in weight in groups of brains classified according to mental power, station, sex, or age. Hence the differences must be mainly due to growth of medullary substance.

head is not more judicious than to say that one could give Siberia a railway system more complete relatively than that of England in the same time.

We may now compare these theoretical considerations with the results of actual observation. M. Louis Lapique, a French scientific worker, recently (1908) communicated, through M. Dastre, to the Academy of the Sciences an important study of the weight of brains in relation to intelligence.

He compared weights of brains of animals of the same species and of different species, and he concluded that the weight of the brain has no more importance in regard to intelligence than the weight of a clock has importance with regard to its keeping time.

I have before me a list of the weights of the brains of famous men. Turgenieff, the Russian novelist, heads the list with a weight of 2,012 grammes. Walt Whitman is at the bottom with 1,282 grammes. Skobeleff, the celebrated Russian general, has 1,457 grammes; while Helmholtz, one of the most comprehensive minds of all time, is less with 1,440 grammes.[1]

Leigh Hunt found by trial that Byron, Shelley, and Keats all had small heads, considerably smaller than his own. Medwin said Byron's head was very small.

Evidently within fair limits the weight of the brain

[1] Wagner (*Das Hirngewicht*, 1877) has published some interesting tables which bear out the general argument of this chapter. Bischoff has another list which shows Liebig, the famous chemist, low in the scale of weights with 1,352 grammes. The celebrated Neanderthal skull, one of the representatives that have been preserved to us of prehistoric man, has, according to Sir Ray Lankester, a cavity of 1,600 c.c. The average European skull of to-day has a capacity estimated as between 1,500 c.c. and 1,550 c.c. Joh. Seitz (*Zeitschrift f. Ethnologie*, vol. vi.) examined two brains from Tierra del Fuego and found nothing to distinguish them from those of Europeans. T. Blakeman finds a skull believed to be Dante's to indicate weight of brain less than that of the average hospital patient and that of Jeremy Bentham hardly superior (*Biometrika*, vol. iv.). This article should be read in connection with one of R. T. Gladstone, "A Study of the Relations of the Brain to the Size of the Head" (*Biometrika*, vol. iv.).

or the size of the head is useless as a guide in regard to intellect.

Professor Stieda, of the University of Koenigsberg, read a paper at the Congress of Anthropology at Strasburg in 1908 which contained remarkable conclusions. Stieda made a special study of the brain of the celebrated Swedish linguist, Sauerwein, who was conversant with fifty-four languages. The second convolution of the left frontal lobe, Broca's convolution, having been supposed to be determined as the convolution for language, Stieda expected to find a considerable development in this region. But there was nothing there out of the ordinary.

Stieda also studied the brains of a number of deaf-mutes, but found nothing abnormal in Broca's convolution. Stieda also affirmed that in most cases it was impossible to distinguish the brain of a man from that of a woman, or the brain of a healthy person from that of a person suffering from a malady, or the brain of a criminal from that of a man of good morality.

Stieda's researches at length brought him to the conclusion that the importance of the convolutions themselves had been overrated, and that attention should be devoted mainly to the development of the grey matter.[1]

On the other hand, Dr. Bernard Hollander in his book, "The Mental Functions of the Brain, or The Revival of Phrenology," published in 1901, indicates in what way in certain cases mental disorders may be shown to be associated with lesions of the brain. Dr. Hollander, however, uses the term "phrenology" with a different meaning from that ascribed to it by Gall.

[1] Stieda was not biassed by prepossessions; Lombroso was biassed. Lombroso makes great play of the size of certain brains in Broca's convolution, but we shall see later (chapter on Localisations) that the theory of Broca does not accord with facts.

Professor Moebius of Leipzig about the same time revived some interest in a special application of Gall's method.

He compared the reports of post-mortem examinations of the brains of a number of mathematicians, and concluded that a part of the brain, to which corresponded a fulness over the external angle of the eyebrow on the left, was usually in these cases greatly developed. The theory of Moebius was ridiculed by most anatomists who looked into it.

More recently (in 1907) another German, Dr. Siegmund Auerbach, after a comparison of the brains of some noted musicians, including that of Hans von Bülow, published a theory that a great faculty of music corresponded to an extraordinary development of a part of the brain which may be indicated as round the posterior portion of the posterior horizontal limb of the fissure of Sylvius, and particularly in the region of the supra-marginal convolution. Very roughly this may be indicated externally as being about the prominence between the top of the ear and the top of the head in a vertical line above the ear.

Auerbach also declared that great development in the same region was likewise found in the case of celebrated mathematicians, notably Helmholtz, Sonia Kowaleski, and Evariste Galois.

Observations of the kind, however, being purely statistical, should be based on a number of observations so great as to exclude all other sources of confusion. It is sufficient here to point out that Moebius and Auerbach, following the same method, arrived at different conclusions.

The shape of the skull is due much more to accidental causes than to the development of the brain. At birth, or before birth, it receives impressions which may persist. Its shape is at that time very adaptable, and the changes

in shape have no apparent influence on the general health of the brain.

Rickets is a frequent cause of a perpendicular shape of forehead which is often supposed to be associated with great intellect. Other diseases influence the general shape of the skull, often giving the forehead a bulging appearance, but certainly without improving the quality of the brain.

Lombroso has founded a theory on the asymmetry found in many skulls. He considers this asymmetry a sign of criminal tendency; but Lombroso's speculations, though based on a great fund of valuable observations, are really as unsupported as those of Gall.

Asymmetry is not peculiar to criminals. It is almost universal, and is due to pre-natal conditions. It is frequently found in a marked degree in the skulls of men of great mental power whose lives have been exemplary. To convince one's self of this it is only necessary to take a walk in some gallery containing the busts of famous men.[1]

Stieda laughs at Lombroso's theories as to the brains of criminals, for he says that investigation does not in the least bear out his conclusions. This is the opinion of most anatomists who have made a study of the brains of criminals. Prof. Debierre of Lille found that the brains of certain notorious criminals were quite normal, so far as could be ascertained in the present condition of science.[2]

[1] Amongst examples of asymmetry Lombroso himself cites Pericles (squill-head), Bichat, Kant, Dante; while Volta's skull had many characters generally attributed exclusively to those of lower races. Deviation of the nasal septum, however, which is a cause of asymmetry, and a contributory cause of other forms, is found in over 75 per cent. of subjects (Morell Mackenzie gives 77 per cent. from an examination of 2,000 skulls. Other observers give figures varying from 53 per cent. to 96 per cent.).

[2] Cf. also E. L. Dallemagne, "Stigmates anatomiques de la criminalité," and Hartenberg, "Physionomie et Caractère" (*Bibl. Int.*). Wulf (*Jahresversammlung des Vereins Hannover'scher und Westphälischer Irrenärzte*, 1889), found in epileptics the weight of the cerebellum relatively less, and the total weight of

Inferior development of body and brain is found in degenerate types, but the ordinary active criminal displays no more marks of asymmetry or degeneracy than the ordinary honest man. It would be strange if it were not so, for the difference between them usually depends on accidents over which neither has any control. I have observed amongst criminals some exceptionally well-shaped heads, just as I have observed amongst some of the most intellectual men in the world heads that, if found in the case of criminals, would have caused Lombroso to cry triumph.

Lombroso extended his theories even to the discovery of marks of criminality in the hands. The photograph of a hand was sent to him with the intimation that the hand belonged to a man who had been guilty of an atrocious crime. Lombroso pressed his science so far that one might say that the crime seemed inevitable. The hand proclaimed the criminal's very destiny. But it was discovered subsequently that the hand was not that of the sinister girl-murderer at all, but the hand of an honest coach-washer.

So far from physical imperfections implying moral obliquity, it will be found that in the imperfect state of civilisation charged with so many incongruities, to which we have arrived, a high state of physical perfection is almost incompatible with great intellectual ability and what we call great morality.

All qualities depend on exercise for their development, and the factors on which depend physical beauty and physical excellence generally are extraordinarily various and complex. The best types of fine bodily development we might expect to discover among the ancient Greeks,

brain also less, than in non-epileptics. He believed there was a connection between mental weakness and brachycephalic skulls, and that in cases of mental weakness the maximum weight was reached earlier than with normals.

who cultivated beauty and harmony expressly, or amongst the best specimens in their prime of some high-spirited warlike people, such as the Goths, the Gauls, or the Highland clans. But the very conditions of the exercises which developed their physical qualities prevented much intellectual advance.

The youth unable to bear arms, the unfortunate hunchback, the club-footed hind, the homely wretch, too unattractive for flirting with the maidens of the clan —these would be the types from whom observation of nature and long-sustained thinking might be expected.

I will not here expatiate on this theme. Suffice it to say that the principle will be found to apply even in our modern civilisation. Byron's club-foot was a perpetual goad to his intellectual faculties. George Eliot's plainness of feature made her seek compensations elsewhere. It is not the beautiful Phryne, but the physically insignificant Charlotte Brontë who thrills the world with poignant works. Balzac's ugliness forced him to seek other means of charming.

Even amongst great leaders of men, it is quite remarkable to find how many of them have been weakly in their young days, and how many of them have borne the marks of deep physical stigmata, from Cæsar to Turenne, from Demosthenes to Pitt.

Medical books, describing the influence of adenoids on the general development, would lead the reader to suppose that a child afflicted with adenoids must grow up little better than an imbecile. But the majority of children in cold damp climates are thus afflicted. One has only to look at a portrait of Wellington, and to remember the two prominent front teeth which he had when young, to find there a well-marked adenoid face. Yet Wellington was not deficient either in energy or wit. Charles V.,

one of the most active of the great rulers of old days, was also afflicted with adenoids.

Dr. Cabanès has discovered an inexhaustible mine in his researches into the physical condition of celebrated men. He has shown the ravages of grave diseases continuing through generations of dynasties and affecting the history of mankind. Here has been indicated for a moment a fertile field of study.

But to return to Lombroso: his theories are borne out so far that in criminals he finds all sorts of physical anomalies and asymmetry; but they are not borne out to his conclusions, for he would find physical anomalies and asymmetry just as frequently in the ordinary man, and perhaps more frequently in men highly distinguished in intellectual realms and leaders of moral reforms.

Certainly in summing up the whole character of a man physical deficiencies, deficiencies of taste, deficiencies of sympathy, must be set down as real defects, although under imperfect conditions they may have aided the individual's success. A blind man cultivates the sense of touch to an extraordinary degree, and a blind man may become famous for this reason; but blindness must be placed on the negative side of the account.

Newton thought little of Shakespeare or Phidias (cf. pp. 410, 421), and his judgment on subjects of this kind betrayed profound deficiencies of nature, even though in the balance the greatness of his achievements compensated for such defects.

These matters should especially be borne in mind in considering opinions in æsthetic matters, or broad principles of morality, where wide knowledge and high outlook are necessary; for there is a danger that a man's limitations may sound in his judgments (cf. p. 311).

Yet withal it seems difficult to exclude certain broad guiding lines in judging of the correspondence of the

intellect and the physique. One would be prepossessed at least in favour of a well-developed head of ample proportions surmounting a countenance showing brightness and strength.[1]

The heads of some men grow in size to an age relatively advanced. Gladstone declared that his head increased in size till the age of forty.

A habit of prolonged and serious thought, particularly in abstruse subjects, will gradually change the shape of the forehead. One might compare, in this regard, the busts of great men of science, as, for example, Descartes, Newton, Huyghens, Kant, Gauss; or of those who, though less systematic in their thinking, have nevertheless been attracted towards profound speculations, Molière, Goldsmith, Goethe. One cannot fail to be struck by the pressing together and the heaping up of the frontal bone over the eyes on both sides of a well-marked central ridge.[2]

The explanation, however, is not to be found in an increased size of the brain, but in the deformation of the frontal bone owing to the pull of its attached muscles. This is found in the attitude of attention and concentration of thought, and is probably due in some degree to the regulation of the blood supply in the brain, so as to secure a good supply to the part in activity and a diminished supply to other parts (cf. pp. 237, 244, 612).

Here we find added another factor helping to understand why serious study and constant exercise in a subject make its processes easier, for by practice the physical

[1] W. W. Wendt ("Alte und neue Gehirn-Problême," 1909) finds the lowest weight in brains of normal persons in the case of day-labourers. The lightest was 1,120 grams; while the lightest in academic circles was 1,140 grams. He believes brain-weights can be established below which no individual in a given class sinks.

[2] Cleland and Deville (*Phren. Journ.*, vol. xiv. p. 32) have shown that the shape of the head changes with the exercise of the faculties.

apparatus serving concentration of thought becomes more readily adjusted (cf. pp. 390, 419, 421).

The study of the physical conditions corresponding to various exercises of thought is interesting and important, and there is still a field here almost unexplored. In thinking intensely on abstruse subjects demanding fine introspection one finds a suggestion of setting up a delicate instrument. This is observable also, although with differences, in subjects requiring constructive forms.

The subject of fatigue may also be studied in connection with this.

Fatigue following a new study of some complexity is indicated by a general confusion (*wir-war*, as the Germans expressively say) of the brain. But when one becomes familiar with a subject, and pushes the study to the point of complete fatigue, the effects seem more local. The interpretation of these effects, however, should not be referred too closely to the local symptoms, but should take into account all the factors. Thus, for example, œdema of the lower limbs may follow insufficiency of the heart's action; or congestion of the liver may produce dilatation of the veins of the œsophagus; so that the cause is not always to be found in the place where its effects become manifest. Thus if following intense application to mathematics great fatigue were referred to a region of the head corresponding to the fissure of Rolando, it would not follow directly that the greatest activity of the brain was referred to that neighbourhood.

The "pregnant brows," to use a literary expression, are the stigmata of the thinker, but the effects of a habit of close thinking are more general. Darwin as a young man seemed to differ in no great degree from the average of men in his situation, and he might have been expected to settle down as a fox-hunting squire. The long voyage in the *Beagle* impaired his physical constitution and

limited his world of exuberant animal pleasures. Moreover, it permitted a course of thought immersed in a certain field of observation and little disturbed by distractions from without. Upon Darwin's return from his five years' cruise his father observed that the very shape of his head was altered.[1]

If one compares the early portraits of Darwin with the statue in the Natural History Museum, South Kensington, one is impressed by the evidence of the effect of deep patient thought in the whole set and character of the head and face.

The type of countenance of a man mighty in council, as for instance a great judge, has been made familiar to us by many examples, and has been well caught by the newspaper caricaturists. The type of a great physician or of a great engineer is not very unlike. We have already seen that the methods of thought are not dissimilar, but the differences arise from the actual objects referred to in the scheme of thought, and the differences of external lives so occasioned. Compare, for example, the countenance of Hawkshaw with that of Chief Justice Coleridge, or Palladio with Bentham, or d'Alembert with John Hunter; or in men of similar pursuits, Dalton, Newton and Huyghens, Gauss and Ampère, or Darwin in later years with the aged Galileo.

There is a certain resemblance of type between Byron and Burns, and even Moore, and, though with more pronounced differences, Shelley and Keats.

There is another type of which representatives are Daniel O'Connell, Daniel Webster, and, though more remotely, Gambetta, Danton, and Mirabeau.

[1] It is curious to note that Capt. Fitzroy was at first inclined to reject Darwin, being convinced that no one with Darwin's nose could have grit or perseverance.

§ III. Bearing of Physiology on Psychology

In the study of physiology the mind is ordinarily occupied with matters that have no more reference to Psychology than has botany, and no doubt the majority of students of physiology complete their studies with no especial reference to psychological questions.

Yet even on the most general lines something is gained if the study of physiology do no more than teach us to adopt from that science those metaphors and forms of illustration which are necessary machinery of language.

But if the two subjects, Psychology and Physiology, be studied side by side, it will be at length impressed on the mind that such metaphors and illustrations are something more than mere helps to language. We become convinced that within the limits of experience certain physical conditions are the invariable antecedents of certain psychological processes. Psychology appears when the play of physical forces is followed by the flash of consciousness, but the greater part of physical activities, even of those which influence greatly our mental life, are not immediate physical correlatives of sensations and ideas. They are the subconscious factors whose resultant appears from time to time in consciousness.

The great complexity of activities which subserve ideas, carried on beneath consciousness, are therefore independent of any control of Will. Acts which have been known in consciousness and which are incessantly repeated tend to become automatic, and to disappear from conscious observation. Their physical foundation persists and becomes organised. Such processes have taken place in our race with gradually increasing stability in development. They have taken place in their beginning with regard to the necessities of the preservation of life and the satisfaction of immediate desires; later with

regard to the control on a more extensive scale of the forces that impinge on life. Therefore in this way we are led to observe that since Reason depends on the resultant of these powers, Reason finds its ultimate sanction in an accordance with the fortunes of our race in the world in which it has been placed.

I say fortunes and not experience, because our conscious experience represents only a small part of the forces that play on us, and it is not possible to affirm that there may not be a wider scope of forces which, though not defined in consciousness, may nevertheless have helped to direct us.

Hence we see both the strength and the limitations of Reason. We rely on Reason because it makes the profoundest appeal of anything we can know; but we rely on Reason only when it is based ultimately on the Fundamental Processes in their simplest exercise.

We have often insisted that physical activities are only the correlatives of mental processes; we may now without confusion take a further step in saying that when once the means of physical combinations corresponding to the mental relations have been determined we may from the study of physical conditions obtain information as to mental states.

The only limitation arises from the want of precision of our knowledge, but we have already seen a great number of instances where physiological knowledge has been of direct assistance.

In a wider study of physiological phenomena we could indicate the conditions found in cases of illusions, hallucinations, visions, ghosts (cf. pp. 312, 315; see also chapter on Dreams, p. 606), and we could artificially produce them if we were allowed free play in experiment. The underlying conditions may be referred to generally as instability of nerve substance, and these are only

exaggerated and pathological examples of what we find in the normal condition as the constructive faculty and the tentative associations on which reasoning is formed.

These conditions are comparable to dreaming (cf. pp. 605 *et seq.*), except that there the necessary lack of control is brought about in a way which excludes in great part impressions derived from the external world. In the case of visions the impressions derived from the external world may be distorted even in their Immediate Presentation, or they may in part be overwhelmed by the uncontrolled storm corresponding to ideas and associations, of which the stimulation is derived from complex internal conditions (cf. pp. 80–85).[1]

But when our studies of physical conditions are extended into the whole field of biology, we find our conception of psychology and of ethics also broadened. The deep problems of growth, development, evolution, studies in comparative anatomy, the adaptation to environment, the means by which that adaptation is accomplished, the view of the whole active world of organic beings, each intent on limited purposes, yet all subserving other purposes that have lain outside their consciousness: all this cannot fail to make impression on our

[1] The importance of the physical base has also bearings on questions of ethics in diverse ways. Even Idealists must admit that certain bodily parts are the instruments by which we receive ideas, even though our knowledge of those bodily parts may be represented in ideas. Therefore we should keep these bodily parts in efficient order so that the ideas with which we deal may be undisturbed and sane. If a man habitually uses a microscope in research he cannot think it a virtue to have dirty lenses. But the whole principle of the ascetics and the people who for various reasons mortify the flesh seems to rest on such grounds. This is merely perverted materialism.

Certainly one must not push the cultivation of physical excellence and physical comforts too far. Even with the microscope a man of defective vision by using his intelligence and knowing what to look for might do far better work than one of keen eyesight.

Life, too, is not a mathematical rule, but an irregular and often an incongruous struggle; so that tactics are important, and everything should be judged in accordance with the whole perspective that lies before us.

ethical views. I make no more than a reference here. But these matters also have an importance in questions of Psychology.

We observe also that this immense activity of living things takes place in a world of non-living things, but which displays to living things an infinite variety of phenomena. The close observation of the environment leads us to the study of the physical sciences; and as even the study of the more limited field of physiology opens up into the physical sciences, we find how intimately Psychology is limited to the whole domain of science.

The day is long past when Psychology might be thought to constitute a specialism of its own. The psychologist should have grasped at least the leading principles of the sciences throughout their range. This is not merely necessary for the better comprehension of Psychology itself; but because also Psychology, by setting forth the Fundamental Processes and the manner of their combination, becomes a part of each science, finds its best field of application in the sciences, indicates the similarity of processes in various sciences, and so becomes recognised as the matrix of our knowledge, or, as we may say, the science of the sciences.

§ IV SUMMARY

In the field of Psychology there is a domain of which no physical or physiological knowledge can take the place. This is the domain of consciousness. To describe thought as a substance or product of the brain is absurd.

Introspection, mental analysis, will always be necessary instruments in psychological work. Psychologists who say otherwise err from ignorance.

Even if we could visualise the ultimate arrangements in the physical activities which precede thought, we could not by this alone bridge the gap between these physical conditions and thought. The state of our knowledge with regard to physical conditions correlated to mental states is very deficient in precision.

Even mental conditions that betray themselves in violent outbursts, such as hysteria, and in some cases lunacy and epilepsy, leave no marks that we can discover in the brain.

Our present system of examining the brain can only give gross general indications.

The system of phrenology has no proper scientific basis; its conclusions are at variance with observed facts.

Size of brain within normal limits has no constant relation to intelligence. Development of brain does not necessarily imply size.

Development of brain in relation to mental processes means opening up of paths and connecting them in a great variety of ways.

The whole problem should be studied in regard to the activity of the brain, the correspondence of that activity to the outward world, the system of associations formed so as not to dissipate energy but to make it effective.

Regard should also be paid to the length of time available, the incorporation, by study, of known results, and the character of the field of study itself in relation to human progress.

In this respect even physical, emotional, or æsthetic deficiencies may occasionally be of advantage.

Lombroso's generalisations concerning the criminal type are as unscientific as those of Gall.

Asymmetry and physical anomalies are often found

in criminals, but no less so among ordinary men, and perhaps more so amongst men of genius.

Asymmetry depends on the one hand on causes quite natural, and on the other on causes quite accidental.

Yet withal the study of physiology has proved of great benefit to psychology. Even the broadest indications are useful.

The principle of construction of the brain affords a good graphic illustration for referring to mental phenomena. Certain localisations of the brain have been successful and helpful.

In a wider view we may profitably study the relation of physical conditions to mental states.

Though we cannot know sensation and ideas directly from physical conditions, yet when once such relations are established we may gain information of mental states by observing physical combinations.

Considerations of physiology in regard to Psychology should not be confined to the nervous system, but should be extended to all the bodily apparatus.

The study of physiology in connection with Psychology at length gives clearer views than could be judged from a single instance.

The study of physiology has ethical bearings. It leads also to the wider study of biology, which enlarges our ethical horizon, and also aids our study of Psychology.

Thence we are led to the study of the physical world. Psychology should be considered in reference to all the sciences; it shows similarities of processes in different sciences. Psychology may be looked on as the science of the sciences.

PART II

RECIPROCAL INTERPRETATION OF PHYSIOLOGY AND PSYCHOLOGY

§ I. Localisation of Functions

It has been an alluring dream among thinkers that eventually the functions of the brain might become so perfectly known that physiology would suffice to explain all mental phenomena, and that consequently psychology would become a sort of corollary to physiological science.

There is much that is plausible in this notion, and as with each advance in research the vistas disclosed seem enormously vast in proportion to what is already known, we can well understand the extraordinary interest excited by the modern examination of the brain, which revealed the course of the nerve tracts in its substance, which threw illumination upon its entire structure, and which in the determination of motor areas, and particularly in the "localisation" by Broca of the "centre" for speech, gave meanings at once vivid and precise to its structure and functions. Enthusiastic students felt that at last we were entering into the very arcana of Nature, and that the meaning of the world and the destiny of man would soon be revealed.

Certainly, even after the critical review of science there remains enough to excite our warmest admiration, but the path to psychological knowledge through that field is intricate, arduous, and misleading.

Had I thought it possible to arrive at a better understanding of mental processes by means of specialisation in that study, I should cheerfully have accepted the tasks, especially as even by the wayside they are full of rewards of discovery.

But in the present notes on the subject it will be evident that the question is so intervolved, the actual facts relatively so meagre, and the inferences from these facts so hazardous, that it is useless to seek guidance for the fundamental problems in that way. It would be a difficult labour to find means of unravelling the tangled skein of physiological psychology, built on the study of the brain, therefore I sought my starting-point in quite another sphere; but I believe that the conclusions we have reached will be of some use in discussing the problems that we now encounter.

For example, the question of Will is discussed by some thinkers amidst a great display of physiological learning in regard to the brain. It is not clear at first what the Will has specially to do with these studies, and even after devout exercise in this discipline of thought I am not able to offer a good answer to such questionings as here suggested.

But just as we discovered in a previous chapter why Biology came to be regarded with especial veneration, so we find here that when a thinker is a student of brain localisation and also a student of Will, he will have a tendency to associate these in his mind, and the science he produces may be less valuable for its objective reality than as a commentary on the workings of the individual mind (cf. pp. 393 and 530). The physiologists have had as a rule unilluminated conceptions of Psychology; the psychologists, at any rate of the older school, have been woefully ignorant of physiology.

That the physiologists are not safe guides becomes evident when we place their statements in juxtaposition; they contradict each other on vital points; they cannot all be right. In regard to their inferences it is possible that they are all wrong.

Munk puts forward a theory that would represent the idea as something actually lodged (*ablagert*) in the cell (cf. pp. 80, 502, 558, 619). Another school of philosophers attempt to localise Will; Hitzig, whose work on the topography of the brain is admirable, thought it possible to localise the seat of the Will, though from all that has been said it is evident that one might as well attempt to localise Memory. But even that feat has been accomplished.

Goltz is opposed to any close localisation of functions. Broca defines the area for speech in the third left frontal convolution. Marie and others find cases of perfectly marked aphasia with this area intact, but with lesions elsewhere.

The conception of an idea imprisoned in a ganglion sounds grossly materialistic, and the formulation of a theory of the kind indicates an incapacity for thinking in terms of Psychology. But the Idealists are guilty of offences quite as palpable. Lotze, who derives ultimately from Kant, seems to hold conceptions of a "seat of the soul" as firmly as Descartes, except that he does not boldly locate it in the pineal gland (cf. p. 502). Yet the school of Idealists feel a sort of aversion to studies in localisation. This is also absurd; for the most fervidly idealist of persons will open his eye if he desires to see. Does he then consider that the external organ so presented represents the be-all and end-all of the visual apparatus? If not, then he must continue his investigations. And he will be led to histological methods. And thence he will find no break in studies that lead to the exploration not only of the topography of the brain, but also of its constitution and functions. But the fear that this portends danger to Idealism, such as we have considered in the chapter on Externality, indicates

once more a crude and materialistic conception of these matters.

That difficulties should arise in regard to theories of localisation such as that of Broca might well have been anticipated by any one who had carefully considered the principles set forth in this volume.

Let us now look more closely into the matter, for though, following upon the assaults of Marie, Moutier, von Monakow[1] and others, Broca's area has been abandoned in as far as localisation for speech is concerned, yet from time to time cases are met with where the symptoms are those of aphasia, and where after death the lesion is found to have affected the third left frontal convolution.

A case examined by Chauffard and Rathery not long ago is notable in this regard. The patient was a woman of sixty-one years of age, who while going about her ordinary business felt ill one day and found it necessary to sit on a chair. She was unable to speak. Facial paralysis on the right side was apparent, and there was also slight paralysis of the arm and hand. Sensibility and ordinary reflexes remained unaffected. The patient appeared to understand everything that was said to her, but she was unable to reply, although she made efforts. She produced only unintelligible sounds. She died in a week, and the autopsy revealed the occlusion of an artery supplying Broca's region.

But to conclude from a case of the kind that this region is the motor region for speech is not justifiable, for all the factors have not been here taken into account.

In the first place, if motor be taken to mean such as move muscles, we must consider that there are not many muscles in the body altogether, roughly some three

[1] F. Moutier, "L'Aphasie de Broca." Prof. von Monakow, "Über Lokilasation der Hirnfunktionen."

hundred.[1] The nervous mechanism for the movements of the muscles in response to sensory stimulation is simple. Thus the centre for the patellar reflex, or knee-jerk, is situated in the lumbar region of the spinal cord. When one knee is placed over the other, and is then tapped below the knee-cap, the leg spontaneously kicks upward. A sensory impulse has been conveyed to the centre in the lower part of the spinal cord and a motor impulse has been given out from this centre, causing the leg to become straightened suddenly.

But all the movements of the body are combined of simple movement of the muscles, so that it is evident that a central nervous structure comparatively simple in type would suffice for the most elaborate motor combinations. In the great beasts of prey we find a perfect co-ordination of muscles in correspondence with the incidents of the outside world, and we observe considerable intelligence in their own way of life, and yet the brain is very small compared with that of human beings.

It is evident therefore that the great bulk of the human brain must subserve the purpose of associations which are far removed from immediate motor necessities.[2]

The associations refer to the element of things, or the ideas corresponding. The principle of development is like that of the formation of words, and of sentences, and finally of a literature, from a small number of letters. If we supposed that each thing had a symbol, somewhat after the manner of Chinese, then the number of symbols would be the number of the possible combinations of Immediate Presentations. This would certainly be an absurdly wasteful manner of building up a suitable brain, and that the constitution of the brain is not formed on

[1] Quain gives 311 approximately. The number is not constant.

[2] There are many other arguments in regard to the structure of the central nervous system which support this conclusion. I have selected one that seems to me to afford the clearest proof.

such a bad principle we know from the study of development, and also from such evidences as have been given in the chapter on Memory, where it was found that each element had its own memory.

Let us now consider a name, first as spoken, then as written, and then in its application to a person. The spoken name itself involves many elements even as mere sounds. But the matter would be simple if it rested with the mere physical impulse of sound, or even with oft-recurring natural sounds intimately connected with the preservation of life. Accordingly the centre for sound must be formed early in the creature's development.

Physiologists seem to be in agreement that the executive centre for articulate speech is in the floor of the fourth ventricle, but even here, no doubt, we are far away from the appreciation of the mere physical sound. Yet on the other hand we are in a psychical world much lower than that of the understanding of the full import of a name.

The executive centre for writing is in the anterior horn of the cervical enlargement of the spinal cord, though in writing we must have an elaborate co-ordination of movements guided by visual and tactile impressions.

If we speak the name we bring into play a new apparatus, and the production of the sound is due in part to the co-ordinated movements of the muscles far removed from the hearing apparatus. Yet the movements must be so adapted that a correspondence is found between the sounds thus emitted and the previous sounds. This requires practice in co-ordination until the emitted sound agrees with the sound first heard. So that for this new advance we need the activity of two parts of the central nervous system which are not in immediate connection.

If we write the name we have a co-ordination of another set of muscles. And if we recognise that the

written name corresponds to the spoken name we have a correspondence between visual impressions, aural impressions, and various co-ordinated muscular movements. But these impressions are related to a very complex thing, say a man; and the full appreciation of the meaning of that term involves the co-ordination of all the various factors which we have found already in the analysis of Externality, and it involves also associations of complexes of ideas of high development. Further to utter the name, or to write it, appropriately involves not only the appreciation of these ideas but also an exercise of Will, and that involves other associations of varied complexes of ideas.

If any of these factors fail, the process will be incomplete. The image which should now be present to the mind is not that somewhat gross conception of a motor area set in motion by a localised Will, as Hitzig would have us believe. The true image is rather that of a whole brain in activity, though the activity may be more intense in certain parts than others, but with these parts changing according to the associations involved, so that a sort of wave of activity passes over the brain, stimulating parts involving ideas derived from all manner of presentations, and referring to a great variety of associations.

In these circumstances strict localisation is illusory. This fact accounts for the discrepancy between the observations of the Broca school and those of Marie and others. For if the stream of successive influences, proceeding from the regions subserving associations of complex ideas to the final outlet in co-ordinated motor impulses, be interrupted anywhere in its course, the process fails from that point onward, and by the influence of shock and other disturbance of function may fail even in parts not directly affected.

But this conception of the working of the brain is

quite consistent with certain regions being particularly involved in the course of the main impulses which proceed to the executive centres. It must, however, be also clearly understood that during a phase of activity in one part of the brain, or even in different parts connected by a stream of nervous energy subserving associations, there is also an act of inhibition over the rest of the brain. In place of any sharply defined "Rinden-felder" (fields on the cortex of the brain), which according to Hitzig control motor impulses, we have strands of communication which may be more numerous in various regions in correspondence with the particular character of the associations and the ultimate muscular movements involved.

Those who have attempted to map out the brain in localised centres have committed errors of the same nature, though not of the same degree of crudity, as those of the phrenologists who have selected a bump on the skull and labelled it "ideality" or "memory"; that is to say, they have disregarded the synthetic character of the development of the brain, and on the other hand they have imagined a system in which the classification is confused and redundant.

The actual history of the subject bears out this statement. The first notable man of science who attempted localisation of brain functions appears to have been Bouillaud, who as Dean of the Faculty of Medicine in France read in 1825 at the Academy of Medicine in Paris a memoir entitled "Clinical Researches to demonstrate that the loss of language corresponds to a lesion of the lobules of the brain, and to confirm the opinion of Gall on the seat of the organ of articulated language." Gall had localised the centres of language in the supra-orbital lobes of the brain. His methods and his reasonings were highly unscientific, but Bouillaud invested these ill-founded hypotheses with a jargon of scientific

terms, and his conclusions were ostensibly based on studies of many cases. Andral, after observation of thirty-seven cases, published his own views and attacked those of Bouillaud. Broca in the year 1861 found ten cases in succession in which aphasia was associated with lesions of the third frontal convolution, but the lesions were really more extensive.[1] In 1865 Broca had come to regard his theory as a sort of indisputable dogma, and it was almost universally so adopted and taught in medical schools.

Professor Marie studied a hundred cases of aphasia at the asylum of Bicêtre in Paris, and examined the post-mortem appearances in at least fifty of them. His conclusions were unfavourable to Broca's theory. But in all these cases, even though with the lapse of years our knowledge is becoming more accurate, we see the evil influence of Gall's crude notions and poverty of thought on the psychological side.[2]

A far clearer idea, not of localisations, but of the veritable function of the brain, may some day be obtained, but that result will be reached only by keeping in view continually the synthetic development by means of lines of communication between elements corresponding to Fundamental Processes and, in progression, by lines of communication between combinations or complexes of such elements. If the principles here set forth be appre-

[1] The history of aphasia introduces some of the most famous names in medical and biological science: Cuvier, Flourens, Gratiolet, Cruveilhier, Gerdy, Frank, Lordat, Abercrombie, Marcé, Vulpian, Charcot, Trousseau, Déjérine, Bastian, von Monakow, for example, in addition to those already mentioned. Wernicke in 1874 published a classification indicating five types.

[2] A discussion on the subject, as well as access to references, may be found in an address by Prof. Saundby before the Birmingham Branch of the British Medical Association, 1910. This is mainly founded on Marie's researches and Moutier's book. Since then I have noticed work on aphasia by L. Bianchi, G. Mingazzini, and E. Rossi, marked by the brilliancy of modern Italian science, and by many others. A succinct account on "Recent Work in Aphasia" will be found in *Brain*, 1909 (J. Collier).

ciated, I believe that we shall be in a better position to consider such a case of aphasia, for example, as that discussed by Dr. Guthrie Rankin at length in *The Clinical Journal* of February 1909. The patient, aged forty-seven, was attacked by right hemiplegia from which a fair recovery was made. He could speak volubly, but his vocabulary was limited. His appreciation of the meaning of words was defective. He could not read print or writing. He was able to write his name but nothing else. He could not read the name after it was written. He could not remember his name so as to speak it. Dr. Guthrie Rankin remarks: "Disturbance of the control centres causes aphasia in the widest acceptance of the term; a lesion of the medullary centres produces anarthria." [1]

The reason of this is that intelligible speech involves something far more than the ability to pronounce sounds, and therefore, in accordance with the principle of development, is subserved by regions more remote in position, and later in epoch of evolution, than the fundamental part of the brain. Dr. Guthrie Rankin points out that there are lower centres in the pons and medulla which control movements of the tongue, lips, and larynx, and of the hand. He says that "the existence of a higher or psychical centre capable of generating independent impulses, which find expression in spoken or written words, has been promulgated by Broadbent, Lichtheim, Wernicke and others, but most observers now agree that the supposition of such an ideation centre is unnecessary."

The supposition of a localised centre involving the totality of all operations of the kind may be untenable, but it follows from the principles of this present exposition that for each effort of intelligible speech, or writing, referring to complex relations there must be a

[1] Anarthria is failure of articulation.

series of communications in regions higher than the "centres" in the pons and medulla, and on the closeness of grouping of the lines of communication will depend the advantage of referring to any locality as a centre.

To enter fully into this particular question would involve opening up the whole subject of brain structure according to the indications offered by various branches of science which bear on that study; therefore I will not pursue the matter further than necessary to set forth the principles.[1]

Of those who have worked in the domain of localisation, Bastian is nearest to this point of view. He says: "In expressing oneself in spoken words the memories of such words are first principally revived in the auditory centre, and then the nerve-units thus called into activity rouse in immediate succession the corresponding glosso-kinæsthetic elements before the pronunciation of the word can be effected through the aid of the motor centres in the medulla. Similarly, when expressing our thoughts by writing, though the memories of the words are probably first revived in the auditory word centre, like memories are almost simultaneously revived, through the audito-visual commissure, in related parts of the visual word centre, and from this region stimuli must pass through corresponding cheiro-kinæsthetic elements before the actual writing of the word can be effected through the instrumentality of motor centres in the cervical region of the cord."

Dr. Guthrie Rankin in expounding this view says: "When, for instance, words are learned, the sensations accompanying their articulation and phonation are located in a centre which, though for convenience called motor,

[1] Recently a great deal of work has been done in regard to aphasia in children. Amongst others one notes Dr. Arthur Edwin Tait, Dr. Eva McCall, Dr. W. T. Rutherford, and Treitel of Leipzig ("über Aphasie im Kindesalter").

is more accurately designated, in accordance with Bastian's nomenclature, the 'glosso-kinæsthetic centre.'"

But it must be noted that the word "sensations" used in this passage is wholly inapplicable. Intelligible speech does not depend on the appreciation of sensations but on a highly developed co-ordination of ideas and complexes of ideas, and all the factors that we have seen emerging in the analysis of Will.

And herein we have also the explanation of facts stated by Dr. Guthrie Rankin in the course of his exposition: "It is well to remember that aphasia may be produced by functional as well as by organic disease of the brain. A right-sided convulsion is often followed by transient inability to speak, and not infrequently the congestive attacks to which general paralytics are liable produce temporary aphasia. Hysteria, or intense emotion, may also give rise to such an inhibition of function as to render the speech-centres temporarily unable to transmit sufficient energy to excite activity in the nuclei of the executive nerves."

§ II. Provisional Consideration of the Feeling of Motor Innervation

It should be observed that every outgoing impulse is not, of course, a motor impulse. In the simplest form of reflex we have an afferent or sensory nerve, a central connection, and an efferent or motor nerve; but in the complex structure of the brain a great proportion of the nervous lines of communication subserve the purposes of association between ideas.

A new question now arises. Has the mind consciousness of these outgoing innervations, or of motor innervations of any kind?

The present exposition has been based on the

supposition that there is a distinct Feeling of Effort accompanying forms of nervous activity both afferent and efferent. It is not meant that every impulse along a nerve makes itself known. Even with regard to sensory nerves whose activities are well known to result in conscious impressions it is not held that every nervous impulse produces sensation, nor that we can distinguish by introspection the strands of nerves that have been affected. Impulses that do not produce sensation may nevertheless modify the phenomena of consciousness. An impulse too weak to produce conscious effects may, by continued repetition, at length produce such an effect.

It was considerations of the kind that led Fechner to the study of the "threshold" of sensation, and Wundt to experiments in the same province to determine the "reiz-höhe," or excitation-height.

On the psychological side we have considered certain aspects of the matter in reference to Discrimination.

But while the position is well established with regard to sensory nerves, it is a matter of dispute in regard to efferent nerves. It would be impossible in the space of this work to deal seriatim with opinions on this subject coming even from high authorities. The very names of experts and their works would form an extensive bibliography. A few observations here and there will be referred to.

Bain in "The Senses and the Intellect" says: "As the nerves supplied to muscles are principally motor nerves by which the muscular movements are stimulated from the brain and nerve centres, our safest assumption is that the sensibility accompanying muscular movements coincides with the outgoing system of nervous energy and does not, as in the case of pure sensation, result from influence passing inwards by ingoing or sensory nerves."

Ferrier enters objection to this hypothesis that it

would make us conscious of the molecular processes of our brains. "If true," he says, "we might have been able to evolve from our consciousness a knowledge of the motor centres which have only recently been discovered after much experimental and clinical research."

It is well to bring forward this argument, for it indicates how misleading may be the views of an histologist or a clinician who gives interpretations in Psychology to the facts of physiology.

Ferrier's arguments could be applied to sensory nerves, and he might just as well argue that the stimulation of the nerves of hearing could not result in consciousness, for then we could evolve from our consciousness the localisation of the auditory centre.

William James is also opposed to the position as stated by Bain. He calls it a "pure encumbrance." This is a question-begging term; it simply means that it is a "pure encumbrance" to the Psychology which he has built up. One is here again reminded of Sidgwick's argument that a certain boulder could not have been found as stated, for otherwise his four volumes would be based on error.

William James proposes to himself the question as to how the notion arises of the feeling of voluntary movement. "I unhesitatingly answer: the aggregate of afferent feeling coming primarily from the contraction of the muscles, the stretching of the tendons, ligaments and skin, and the rubbing and pressing of joints; and secondarily, from the eye, the ear, the skin, nose, or palate, any or all of which may be indirectly affected by the movement as it takes place in another part of the body. The only idea of movement which we can possess is composed of images of these different afferent effects. By these differences are movements mentally distinguished from each other, and these differences are

sufficient for all the discriminations we can possibly need to make when we intend one movement rather than another."

This quotation exhibits in short compass certain typical vices of argumentation. It really leaves the main problem untouched. No one has disputed the operation of the afferent nerves. But the question is as to whether that is sufficient to account for all we know of the movement of limbs. William James by the use of phrases such as "which we can possess," or "we possibly need," is simply employing forensic arts of emphasis. And we are not advanced when he asserts: "I unhesitatingly answer." What we desire to know is not so much whether any particular exponent holds his opinion strongly, but merely what in Nature is the truth of this question.

Now Muensterberg cites Erb, the great neurologist, for cases of ataxia without anæsthesia, and anæsthesia without ataxia. I would not care to affirm that these instances alone are decisive against William James, for one can never be sure that the anæsthesia is complete in regard to all kinds of sensation; but such cases ought at least to prevent a philosopher from unhesitatingly answering in a contrary sense.

Weber cites from various observers, great surgeons and others, a number of experiments on the successive loss of impressions under anæsthetics, and since his time the question has been frequently studied. It would appear that more exact descriptions are required than that of the term "anæsthesia." And at each stage of the successive loss of particular sensations it would be interesting to study the effect on movements.

Weber, long before William James, had not only declared for the consciousness of efferent innervation but he had given good reasons for it: "It is very

interesting for the theory of the Sense of Touch and Gemein-gefühle (general sense, or general somatic feeling) that in addition to the organs of touch we possess a second class of organs, which afford us an impression of the magnitude of the pressure or the pull exercised upon our body: these are the voluntary muscles with their nerves and the central nervous system. From the feeling of effort of these, when we lift a weight, and from the feeling of tension of these, when a weight drags upon relaxed limbs and so stretches the muscles, we form conclusions as to the magnitude of the weight working upon us or of the magnitude of the resistance which we must overcome in moving our limbs."

Weber's experiments show that by the feeling of muscular exertion which he has indicated, differences of weights may be detected when they are in the proportion of 39 to 40. The fineness of discrimination of the sense of touch on pressure was less, the most favourable showing perception of differences when the proportion was 29 to 30.

I do not wish to enforce Weber's authority. Further, I do not think that his experiments are conclusive in this matter, for those who deny the feeling of efferent innervation might say that the sense of touch or pressure should be supplemented by that from the joints, and so forth.[1] To support my position I would ask that statements such as those of Weber and of Bain should be considered in connection with the whole previous exposition of the Feeling of Effort and of Impulse, and with the analysis of Will that will be further continued in this chapter, and that all this should be aided by

[1] A. Goldscheider, whose work in this region is admirable, demonstrated sensory nerves in the joints. Huber and De Witt found sensory nerves in tendons and muscles ("A Contribution on Nerve Tendons in Neurotendinous Organs," *Journ. of Comp. Neur.*, vol. xii.). Golgi had already, in 1890, written: "Sui nervi nei tendini dell' Uomo" (*Mem. della R. Acad. dell. Sc. de Torino*).

patient introspection. The objections may then be carefully weighed so as to ascertain if therein anything further can be found than affirmation, even though insistent or in the manner of authority.

Even in cases when a great display of neurological learning is shown it should be carefully investigated in how far this learning, even if all valid, really bears on the precise point. It will generally be found to have but a remote relation. An authority, say, has based his position on his own introspection, or has seized for some reason upon an opinion; he then discourses elaborately upon the topography of the brain; finally, he reasserts with conviction his previous opinion. But if the argument be regarded closely we shall find that in the statement of the physiological results there is a psychological gloss not at all warranted by the actual objective facts revealed in the study of the brain. To take a gross example: Hitzig, who sought to locate the Will, never saw in the finest microscopical specimen any trace of the Will residing there, nor did Descartes before him ever behold the soul sitting on the pineal gland.

Ferrier is opposed to the theory of motor impressions. "In favour of the existence of a consciousness of effort, apart from afferent impressions conditioned by muscular contraction, various considerations have been offered, some of which are of little weight."

He gives in support of his own views arguments which, as far as I can judge, should rather be cited for the opposite theory: "The patient suffering from central motor lesion, after making futile attempts to carry out his ideally realised movement, not uncommonly bursts into tears at his failure. There is no defect in idealism, but only in the realisation of the movement."

In this instance the lower motor tracts are intact. What fails in the case is the passage to these lower

tracts. Now judging from ordinary sensation, though the original stimulus from without is required, yet the activity of the brain suffices for reproduction. It would seem to be sufficient also for the appreciation of a muscular movement which had been formerly realised. It is true that Ferrier says there is a central motor lesion, but he has left enough of the brain active to subserve his own theory, and therefore it is not asking anything additional that it should be sufficient also for what I consider to be the true theory. The limb is not moved, therefore the elements from which Ferrier could build up the feeling are not available, yet the Feeling of Effort is there; for otherwise what is the meaning of "futile attempts"?

This Feeling of Effort is doubtless not quite comparable to that of the Feeling of Effort in the case of a normally executed movement, but neither is the voluntary reproduction of a visual sensation quite comparable to the sensation itself. I would, in short, add Ferrier's instances, though not Ferrier's interpretations, to what I have already said in favour of the opinion here maintained.

Bastian says that the so-called motor centres are in reality sensory. Muensterberg agrees with this. Bastian refers to the "unfelt impressions which guide the motor activity of the brain by automatically bringing it into relation with the different degrees of contraction of all muscles that may be in a state of action."

Ferrier objects that movements are conducted even with absence of the cerebral hemispheres.

To this we may reply that certain movements of limited complexity only are so conducted. But in the whole course of this exposition we have noted the tendency of frequently repeated acts in association to

become automatic, and we have seen that in the exercise of the Fundamental Processes when the conditions are established the mental act is so far automatic that it is inevitable. The more complex the conditions of reasoning the more extensively the higher regions of the brain become involved. And the hemispheres of the brain are necessary also to the carrying out of elaborate processes even of movements adapted to complex external conditions.

The consideration of such problems has given rise to the question whether muscles have sensibility, and even on this point there is a wide divergence of opinion. Weber thought they had, but still held, as we have seen, to the belief in the feeling of efferent innervation. Ferrier agrees with Weber in regard to the sensory nerves and muscles, and on this basis sees no necessity for motor-feeling. Duchenne on the purely physiological side finds sensory nerves in muscles. Wundt questions as to these sensory nerves, but finds an agreement with Weber on the second position. In his "Menschen und Thier-Seele" he says: "The strength of the sensation is dependent only on the strength of the mental impulse passing onwards through the centre, which acts on the innervation of the motor nerves."

From a comparison of these deductions from physiology, which I have noted out of a great number equally incongruous, it is evident that in many instances physiological psychology is, as has been especially said in the case of Wundt, simply Physiology plus Psychology.

William James uses the argument that when the external rectus of one eye is moved the internal rectus of the other eye is moved correspondingly, and we are unable to discriminate the impressions. Certainly when the images derived from both eyes coincide we

do not seem able to discriminate, but neither can we discriminate when tactual impressions of two fingers coincide. When, as in the case of squint, the two images do not coincide, then it is possible to discriminate with respect to the Feeling of Effort involved, for the person may sometimes try by moving the squinting eye to make the images agree.

The fact, therefore, is not entirely as stated, and, moreover, if it were it would not sustain the position deduced from it. The question is simply one as to the limits of discrimination. Thus if two hard points be brought close enough together in any part of the body, the discrimination of the separate touches vanishes, and on certain areas of the arm or of the thigh the discrimination is so little precise that if the section of a hollow cylinder of two, or even three, inches in diameter be laid on the part, the impression produced will not differ from that produced by a solid cylinder. But no one would adapt the argument of William James and deny that sensation of touch existed.

Weber found that the tip of the tongue was fifty times more sensitive than the upper part of the arm or of the thigh. Correspondingly we have a series of degrees of discrimination on the motor side. We move fingers that are innervated from closely neighbouring sources, and we recognise the different feelings involved in the respective movements.

In order to settle this interesting question of motor-feeling, Bernhardt (*Archiv f. Psychiatrie*, 1872) imagined a critical test, for he thought that muscular sense must depend on centripetal impressions if discrimination remained good when the muscles were made to contract artificially by means of electric stimulus. He concluded in favour of the motor-feeling.

Ferrier disputes these conclusions, and he says

that if weight be estimated by the impression of cutaneous pressure alone, it requires a difference of one-third of the original weight to produce a distinctly perceptible difference of sensation. Here he is wrong on the point of fact according to Weber, who found the difference to be sometimes as small as one-thirtieth. But if Ferrier's figures were right Weber would draw from that fact the opposite conclusion, and I cannot but think that once again Weber would be right.

The question of the Feeling of Effort is especially interesting because it has been bound up with that of Will. Here again the school that derives from Fechner and Weber have pursued the subject in the field of experiment with results which at least are wonderfully interesting in themselves—as, for example, Brieger's experiments in forms of muscular contraction, Toppel's experiments on the influence of amyl-nitrite on the activity of the Will, and those of Kräpelin in this and allied regions.

Schiff, who did great work in tracing out the strands of nerves in the brain, declared for motor localisation, but he thought that the movement followed what was psychically some form of representation derived from the periphery. In other words, his position in this respect was similar to that of William James. Schiff did not consider the motor district to be a veritable motor centre, for this he thought lay deeper in the development. He concluded also that the motor area was not artificially stimulable. Exner and Paneth performed experiments which, they believed, proved the contrary, but these experiments may have other interpretations.

One of the most original and interesting of the German thinkers in this realm is Ernest Mach, who in a work which has been translated into English, "Space and Geometry in the Light of Physiological, Psychological,

and Physical Inquiry," has discussed the relations of the axis of the body to our notions of space. Mach, like Hering, has moreover not been content with saying that each organ of sense has its specific energy, he seeks for physiological, and ultimately chemical and physical, conditions for our mental states. It is well to consult his work, "Die Analyse der Empfindungen und das Verhältniss des Physischen zum Psychischen," published in Jena, 1906.

We will subsequently resume the discussion of the problem.

§ III. The Problem of Will approached through Physiology

Binet's "La Psychologie du Raisonnement" is a very interesting book, but I do not find it at all conclusive; for had I done so I would have considered this present exposition, which really derives from the study of reason, as superfluous. I do not know any French book in the psychological domain which is really entirely original and basic (*grundlegend*, as the Germans say), though there are numerous interesting treatises. I do not say this in discredit of French intellect, which has produced in various spheres so much that is marked not only by the brilliancy of genius but also by the solidity of labour; but that makes it only more remarkable that no figure exists in France comparable in the realm of psychology to Locke or to Spencer. Condillac, whom John Stuart Mill disparaged for fastening on the weaknesses of Locke, seems to me to have been worthy of a much more appreciative criticism. It was the constant endeavour of this great and sincere French thinker to analyse the nature of reasoning, and to direct his analysis to the elements of the process of thinking. The main problem of Condillac

is not unlike that which has been here proposed; but I do not consider Condillac's analysis either fundamental enough, or lucid enough, or sufficiently free from involvement. Condillac's efforts are very remarkable for the period in which we find them.

When I consider, however, the work of a modern school of French writers, and contrast with the heavy obscurities of official German philosophy[1] the clearness of the expression and the activity of these bright minds, it is there that I am inclined to look for the lead in future developments. Even where I cannot wholly accept the philosophy, as in the case of M. Boutroux, I feel my spirit nevertheless invaded by the charm of style. But I cannot find that in any French thinker the purely technical work of analysis has been carried out to the last resort.

Binet points out the baffling nature of the problem of reasoning. One old French school contented itself by saying that we reason by a faculty of reasoning. This is vaguely reminiscent of Molière's comedy. Others say that the problem is "irreducible." Taine does not offer a solution. Binet notes the lacunæ in works when he inquires: What is reason? The analysis of Wundt, who reduces it to sensation, or that of James Mill, who is satisfied with association, are too bare; they do not consider all the factors.

Binet is not content with describing mind merely as "that which reasons." And here it may be said that we do not find additional illumination from such definitions of mind as that offered in the "Analytique de l'Esprit

[1] This refers exclusively to what one might call the established, orthodox forms of German thought, those pretentious systems which, amid a bewildering haze of language, redolent of Kant, Hegel, or Lotze, seek to reconcile the march of intellect with the ethics of the barracks or the nonsense of mystic dreams. For the genuine work of German men of science, work becoming more and more important in the field of Psychology, I have profound respect. The proof may be found in the references given throughout this exposition.

humain et de la Vie" by Dr. J. A. Molinié: "A faculty of high differentiation as a superior polarisation of energy which it co-ordinates or unifies." Binet is content with Herbert Spencer's exposition, and this he epitomises by the term "classification of relations." Binet himself formulates a "law of fusion," and he cites suggestions of Lotze, Wundt, and Helmholtz playing round the same notion.

But whether their positions could be established as true or not, what strikes us particularly is that the analysis has not descended to the elements so as to show how with these elements all processes may be built up synthetically. That has been the central problem of this book; if the analysis here presented were insufficient, or in some other way faulty, yet even the gainsayers would find that the true solution would be obtained by rectification of that analysis. Once that sea has been sailed, no other route can be thought practicable.

In the question of Will Binet cites Ribot with approval: "The 'I will' gives evidence of a situation, but does not create it. Volition, which former psychologists have so often observed, analysed, noted, is not the cause of anything. Acts and movements which follow result directly from the tendencies, sentiments, images, and ideas which have arrived at co-ordinating themselves under the form of a choice. It is from that group that comes all its efficiency."

But the whole pith of the question is, What is the meaning of co-ordination under the form of choice?

Ribot introduces by a preface a work on "Attention" by Jean Paul Nayrac, in which the following passage occurs: "Attention is a general phenomenon which has a repercussion on all the psychical life and necessitate the co-operation of all the principal functions of th

organic and mental life. It should be placed in the highest scale of the psychical hierarchy; with the aid of effort and will it forms our faculty of mental adaptation." William James, on the other hand, it may be remarked, considers that effort and attention are one and the same. In the course of the work Nayrac discusses whether the motor or the sensory side plays the more important part in attention, and there is found the usual divergence of opinion of celebrated physiologists and psychologists.

In Nayrac's passage I find terms used that are as difficult to define as attention itself. It seems to me that what I would mean by attention involves the Fundamental Processes particularly of Unit, Immediate Presentation, and the Feeling of Effort; and read in this light the character of Nayrac's passage is clearer, and the difficulties of the physiologists are capable of solution (cf. p. 578).

Some may have expected to find a factor of Will in attention, but I think that if the matter be closely regarded a distinction may be made. Thus, for example, we may by exercise of Will place ourselves in a situation to receive a sensation, but the sensation is not to be confused with the act of the Will. The subject is, however, in part a matter of definition, though that again involves a question as to the degree of analysis. If Impulse, as a factor of Will, be thrown into relief, then we have a more determinate act of attention, and one involving an addendum to that previously considered. Similar remarks, in regard to diversity of application, would apply to attention as to Will.[1]

[1] So vast is the literature of Attention and so full of vitality—one of the latest works comes from Buenos Aires: R. Senet, "Teoria de la Atencion"—that it seems hardly professional to dismiss it incidentally. Yet the fact that other syntheses—Memory, Will, Judgment, or what not—have been taken as the keystones of systems simply indicates the necessity for analysis to the Fundamental Processes. In this view the matter becomes clarified.

Ribot in his book, "La Volonté," offers explanations which give to Will something more distinctive than would appear in the passage cited from that book by Binet: "Will, on the contrary, resolves into volitions of which each is a 'moment,' a form instable of activity, a resultant varying according to causes that produce it."

This passage, if read in the light of all our present exposition, and expressed in accordance with the terms employed, is not unacceptable.

Further, Ribot disagrees with Maudsley and Lewes, and consequently with the whole school of James Mill, that Will can be analysed to an "excitation caused by ideas." He objects that this is simply a case of "laissez faire." He says of Will: "But it is quite another thing. It is also a power of arrest, or to speak the language of physiology, a power of inhibition."

The mention of inhibition suggests the research by the physiologists of the "centre of inhibition," and we have the inevitable discrepancies based on the usual deficiency of analysis. Setschenow places the centre of inhibition in the region of the optic thalamus and the corpora quadrigemina; Goltz and others in the cortex; Ferrier opines for a moderating centre in the frontal lobes. As well might we search, it seems to me, for the centre of Memory or for the centre of delight.

In conclusion Ribot seems to weaken in his appreciation of Will. He does not accept the "laissez-faire" doctrine, but his own analysis is not definite. Previous to the passage cited by Binet we find: "Volition is a state of consciousness which results from co-ordination, more or less complex, of groups of states, conscient, subconscient, inconscient, or purely physiological, which all united are translated into action or inhibition."

Of the great mass of literature on this subject a contribution which deserves to be specially noted is that

of the great biologist, Loeb. His analysis of Will agrees with that of the James Mill or William James schools. He says that the notions of the metaphysicians with regard to the Will are the outcome of an illusion due to the necessary incompleteness of self-observation. And further he remarks: "I think that we are justified in substituting the phrase 'activity of associative memory' for the term 'consciousness' used by the metaphysicians."

Here we find evidence of the impatience of a scientific worker in the presence of the absurdities of that mediæval philosophy which is so carefully nurtured in our Universities. But in ridding himself of the notion of an entity, Will, Loeb has been carried too far; for he gets rid of Will entirely. We will see what this means in discussing the position of Muensterberg; but before leaving Loeb it may be observed that in these discussions he allows his mind to be dominated by his theory of ions. Even in a sphere where this theory was particularly applicable, that of parthenogenesis, Loeb has regarded it too exclusively, as is evident from the results obtained by Delage and Bataillon (cf. pp. 489, 490).

We have already had occasion to note the influence of special studies in restricting a man's view in the cases of Newton and Young and others; and certainly it must be a far cry from the theory of ions to a theory of Will, and Loeb's references to ions serve less to settle the question of Will than to illustrate former remarks on the wider scope of Association (cf. pp. 393, 530, and 651).

Of the various authorities who have declared against the Feeling of Effort as applied to motor nerves, one of the most formidable is Muensterberg. His work, "Ueber Aufgabe und Methoden der Psychologie," is marked by erudition and patient thought, but even here the influence of mere authority is not eliminated. Muensterberg is a disciple of Fichte, and Fichte was a disciple of Kant, and

Kant proceeded from certain doctrines which, though not discovered in analysis, he held to be cardinal.

Muensterberg's system might be described in the main as Fichte plus physiology. His analysis of Will is virtually like that of James Mill; yet withal the old Kantean influence prevails and he holds to an "ethical Freedom" associated with a conception derived from Schopenhauer of a sort of Universal Will. All these accompaniments, however, whether true or false, escape from the realm of demonstrable science. They belong either to the free play of a philosophic fancy or to the tribute which even the most modernised thinker may feel incumbent to offer to the ghosts of his ancestors.

If the argumentation of this book depended at all on authority I should be glad to extol that of Muensterberg, for on a certain question, which is perhaps the most difficult in this whole exposition, I could claim his support. I refer to the position of the Unit. Muensterberg here seems to me to be excellent. He explains the difficulty of accepting the position (1) by the rapidity of the movements of the mind; (2) by the fact that the Unit is nearly always a complex—that is to say, something that in our subsequent analysis we discover to be composite (cf. pp. 86 *et seq.*).

His analysis of Will is also good except that he seems to me to miss the essential. He is too much concerned in removing the notion of the entity supposed by metaphysicians. Then again in reading Muensterberg one must be on guard against the weight of physiological learning. It has been made abundantly clear in the course of this chapter that on very important points, and points that are fundamental in regard even to the objective science of brain topography, there is a disagreement on the part of eminent authorities; there is far greater disagreement with respect to the deductions in Psycho-

logy; and as few of the physiologists have shown a clear apprehension of analysis in Psychology, it may happen that in the midst of these disagreements the truth still remains remote and intangible.

Yet certain sciences have impressed the minds of thinking men as so closely related to ethical or psychological studies that the authority derived from them is apt to be "octroied" into domains with which they are only remotely connected. Thus the authority which Herbert Spencer derived from his exposition of the principle of Evolution is found to support him in his very insufficient analysis of style (cf. p. 503). Huxley's studies of biology aided his opinions on the Gadarene swine in his celebrated and amusing controversy with Gladstone (cf. p. 359). And when Muensterberg, with his Fichtean philosophy and his determination to shatter the scholastics on Will, has arrived at certain conclusions by his meditations in Psychology, and then discusses the intricacies of the topography and functions of the brain, and then finally reaffirms his position, we are apt to conclude that his arguments have been reinforced by the weight of positive science. If the matter be carefully examined it will be found that physiology cannot touch the essential point at all.

Let us take, for example, an argument of Muensterberg's in objection to Munk. In considering the factors that form our impressions of muscular movement, Munk extended the analysis of his predecessors by adding to touch, sense of position, and of pressure, what he called "Innervations-Gefühle" (Feeling of Innervation).

Meynert in his "Psychiatrie" expounded the position more fully and not without brilliancy. Muensterberg, however, puts forward an answer that reflex never becomes changed into voluntary movement.

In the first place there are instances where observers

have been able voluntarily to regulate a mechanism which is ordinarily reflex. Weber could quicken the action of his heart, or make it slower. Fontana is said to have had power over the contraction of his iris. On the other hand, it is hardly necessary to refer to the principles of development which account for the tendency of invariably repeated sequences of the body or mind to become automatic.

Even when associations of ideas are peculiar to an individual it may be possible by force of habit to establish a sequence which will tend not only to reproduce itself irrespective of voluntary determination, but even in spite of some effort to the contrary. That any person should be able to control such deep-seated reflexes as those of the heart or of the iris must be due to exceptional conformation which has permitted a sort of organic analysis. One would be very critical in watching such an experiment to make sure that the reflex was affected by the direct exercise of will and not by bringing about conditions so that the reflex became affected normally.

Be that as it may, it will be granted that at a certain level of more recent development we reach associations which normally occur in a certain sequence but which by deliberate intention may be altered. This is true with regard to certain sequences of ideas and sequences of motor acts.

The objection contained in Muensterberg's remark seems to arise from the consideration of a simple arc of reflex acts, as, for example, that of the patellar reflex, or knee-jerk. Even this simple act, however, is not entirely removed from the influence of the higher regions of the brain. The knee-jerk is sometimes difficult to obtain if a patient who knows what is expected thinks of it too anxiously. If the patient be directed to grasp his hands together and pull, the knee-jerk is aided or "reinforced."

Therefore in cases where no impression is made in consciousness it does not follow that the state of consciousness is not modified. Instances of the sort simply illustrate that there is a limit of Discrimination in regard to all observed phenomena.

Muensterberg finds no psychical term between the afferent and efferent impulse. He affirms this with regard to complexes of movements in the higher regions, and he conducts his argument thence to deny altogether the "Innervations-Gefühle" and finally to exhibit an analysis of Will which seems not to explain Will but rather to explain it away.

Now no one doubts the psychical phenomena correlated to excitation of sensory nerves. Yet we may have sensory nerves excited at times without representation in consciousness. We may have associations, formed with difficulty, repeated at length mechanically. And, what is the most important of all, we have seen in the ultimate analysis that the Fundamental Processes take place automatically or naturally, when the appropriate conditions are presented. Muensterberg's objection in the case referred to contains no valid argument.

Muensterberg declares that it is difficult to observe Will, firstly because the attention required alters the conditions, and secondly because in addition to what is observed Memory supplies something derived from assumed standpoints.

But these objections apply to many problems in the field of mental analysis. We may propose a mental act and watch its operations without the essentials being greatly deranged. The second objection is perhaps more serious. It must be met by exercise of sincerity, by striving after clarity, and by practice in observation. Muensterberg himself, in spite of the difficulties of the problems, yet arrives at decided opinions: "There is

not to be found in consciousness any single will constant for every content, but only innumerable separate acts of will."

With this statement I am in accord if it be interpreted to mean that an analysis of Will is possible corresponding to that of Memory, wherein it was shown that nothing existed in the nature of a constant power of Memory, but that each element of consciousness had its Memory.

But Muensterberg adds something, that to me is unacceptable, to the effect that these acts of Will are "formed by separate impressions and representations derived from recollection."

In another passage he remarks that one remembers a man with all form and colour relations. Here I think there is evidenced a failure of analysis with regard to Memory, as will be observed by reference to the chapter on Memory.

Moreover, on the actual point of fact a remarkable contradiction comes from Binet, who cites the case of a man who remembered most things about his wife except the colour of her hair. Such a case, though rare, seems perfectly intelligible in the light of the analysis which shows that each element has its own Memory.

In another place Muensterberg says that every ganglion is the end-organ of a centripetal impulse and the beginning of a motor impulse. This is only acceptable if for "motor" we substitute "out-going." He believes that the cause of central excitation in the motor apparatus is nervous centripetal stimulation.

But here, as all through Muensterberg's exposition, we have a conception of things derived too closely from the type of the simplest reflex arc. How is it possible that a nerve-apparatus could be formed so that in spite of the infinite complexity of external things, it puts forth

again the appearance of these, preceding movement and subsequently agreeing with its result, form the only ground on which we designate the movement as voluntary."

At this stage I would again bring to mind the experiment wherein a block which looks like lead, but is in reality aluminium, is lifted. The movement is voluntary, but the subsequent impressions do not correspond to those which were anticipated. It may be said that these anticipations were formed from remembered impressions, but that implies nothing further than that the motor impulse is estimated by experience. What is unavoidable in this instance is the conclusion that a certain amount of nervous energy has been stored up previous to a movement, and that it has been released, and has made itself known in consciousness by virtue of that release.

That is not at all the only ground on which I conclude as to the Feeling of Effort; it is but an argument in point in this exposition. Muensterberg gives an analysis of Ego with which my own has a fair correspondence. He says, however, "there is no particular Will," and I would reply that those who read his analysis will have just as good ground for saying "there is no particular Ego."

The desire to cast out the "non-material factor" of the metaphysicians has carried the analysis of the Mill school too far. But when without any of these presuppositions whatever, but with the desire only to ascertain the processes of Nature, we examine their arguments, we find that though it is perfectly true that sensory impulses serve as guides to the measure of motor output, yet the motor output is not merely mechanical or automatic as an immediate consequence upon the sensory stimulation.

In holding the arm out horizontally and as motionless

as possible for some time there is found necessary a considerable exercise of what is ordinarily called Will. No doubt the sensory conditions change, but suppose then we suddenly let the arm fall passively, it will be said that the change of this Will means nothing more than an anticipation of the sensations accompanying the fall of the arm.

It will be observed too that when in the gross popular appreciation Will is conspicuously exercised it is not in those organs abundantly supplied with sensory nerves of high delicacy, but in the movement of massive muscles concerning the existence of whose sensory supply physiologists have been at variance.

One observer, Gaule, says roundly that Will is "known directly in absolute reality." This reminds one of the position of the Common Sense school with regard to Externality. The comparison may be carried further. The Idealists imagined that it was their task not to elucidate from their standpoint the meaning of Externality, but to deny its existence; and so Berkeley, for instance, was led to all manner of absurdities, inconsistent with the principles of his fundamental position.

Similarly, while it is very commendable to eliminate from the analysis of Will all but its essential factors, the Mill school brought it to a point that it is equivalent whether the mind submit passively to the play of impressions from without or assert itself to give definite direction to its progress.

Can the mind so direct its operations? Certainly, for otherwise how could we talk of reasoning? How could we talk of the intention of holding up this intricate problem to our vision till we find in it clear lines of guidance?

What Muensterberg has succeeded in proving is not that the peripherally derived impressions and their

associations form all that is known of Will, but that the exercise of Will is determined by conditions of which they afford information. For the mere purpose of making the meaning clearer this may be exemplified by an analogy: A leader of troops comes to the junction of two roads; he must decide. He gets reports from all quarters, he forms his opinion. But an important factor that helps to mould his judgment is his own quality as a commander. A bold man may take a course which a weak man would avoid.

He decides. That is an act of Will. Now the impressions arising from sending troops along the appointed road may or may not be immersed in new impressions from the road, but in any case the anticipated impressions or the actual impressions do not compose the act of Will, though, again, they may determine step by step the due exercise of Will.

Just so, all the complexes that Muensterberg describes form forces from which a resultant is obtained; but the resultant is not the same whether the person be passive or be active in determining the new direction of thoughts; in that difference Will is found.

Now "*Innervations-Gefühle*" may or may not be recognised apart from this act of Will. I am inclined to think that, generally, it is not recognisable as distinct; although it may still determine the impression of Will, and then step by step modify the Will, and also help in determining the subsequent amount of innervation.

Here I would say, what it might have been confusing to have noted till the terms had been under discussion, that *Innervations-Gefühle* does not seem to me to be the same as the Feeling of Effort. *Innervations-Gefühle* has been taken to mean the sense of innervation of efferent nerves. But even here a distinction

may be called for. Does this feeling arise from central excitation, or become manifest only when the actual motor nerves are innervated? If we may judge from what we seem to know in a much clearer manner in regard to sensory nerves, the central excitation is necessary to produce conscious impressions, but the character of that central excitation, and hence of the impression, is modified by the happenings which extend to the periphery. Hence in the case of effort to move a paralysed limb we find *Innervations-Gefühle* even though not comparable to that of normal movement.

But the Feeling of Effort seems to me to apply both to afferent and efferent innervations. To demonstrate this with regard to sensory nerves is difficult, though if my intention were merely polemical, I could turn the tables on those whom I have been lately endeavouring to controvert and say that they have established it for me. For in showing how the sensory nerves contribute to the formation of *Innervations-Gefühle*, they recognise the existence of the *Innervations-Gefühle* in spite of their subsequent conclusions that it is a superfluous assumption.

However, I wish to get nearer to Nature. I will endeavour to make my meaning clearer by saying that apart from the specific differences of sensations, there is something common to all sensations, a sort of groundwork from which the various sensations have been differentiated, and which indeed enables us to speak, by Generalisation, of sensation. This is manifested by a Feeling of Effort in the receipt of each particular sensation.

It becomes manifest at times, as when one is expecting to hear a mighty blast of a trumpet and a feeble piping comes, or in conditions of an opposite kind.

It is possible to say that here there is a confusion; that in addition to the actual organs of sense the sensory apparatus requires the co-operation of various setting-up movements involving motor nerves, and that the shock of failure in the one case, or of surprise in the other, affects the complex of motor nerves, and that the Feeling of Effort here is simply the *Innervations-Gefühle* already described.

This is a matter which may not be decided offhand; but I think that if the question be approached without prepossessions and be continually kept in mind even for a considerable period, so that observation be continued until the entire subject is familiar and clear, a conviction will arrive at length that the Feeling of Effort applies also to sensory impressions.[1]

There is no necessity to repeat the arguments with regard to its manifestations in efferent nervous excitation. In this series of phenomena Impulse holds a relation to the Feeling of Effort analogous to that which on the sensory side sensation holds to the Feeling of Effort. Impulse, considered in relation to the Feeling of Effort, is the more intellectually definite, and according to circumstances more differentiated, determinate activity of the mind which occasions and is associated with the Feeling of Effort.

An objection may here be urged that as the Feeling of Effort is a concomitant of Immediate Presentation or of Impulse, it is indistinguishably merged into one or the other. That does not necessarily follow. We hear a shrill sound, for example; it might be said that the meaning of that sensation, or Immediate Presentation, of sound, is the total of all that is con-

[1] It is accepted among psychologists that intensity is one of the qualities of sensation. Why, therefore, did I not adopt this as one of the Fundamental Processes? Simply because Feeling of Effort is more general, more basic. This question and answer will, however, serve to establish the matter more clearly.

tained in its appreciation. But Time is an invariable concomitant of sensation, and Time is an invariable concomitant of any process whatever; and so it becomes possible to speak of Time without immediate reference to any particular sensation.

Or again, when we look at a coloured object we appreciate its form also. It is impossible to think of a coloured object without form. But form is not colour, and we can speak of form, as of colour, without reference to any definite object in immediate contemplation.

Therefore, even while recognising the closest association between the Feeling of Effort with Immediate Presentation, or with Impulse, it is possible to consider it separately. Impulse is the activity of the mind that brings the corresponding Feeling of Effort in its train.

Another objection more subtle may be thought of: In sensation we have clear differentiations of sensation, but how is this possible with regard to Impulse?

The answer is that the matter involves considerations of the limit of Discrimination, and of practice in observation, while the observation itself in the case of Impulse becomes examined by means of introspection, but that if all these factors be taken into account we shall find differentiations of Impulse corresponding to those of sensation.

Those who, like Muensterberg, deny *Innervations-Gefühle* really help us to the understanding of differentiations of Impulse; for though they deny the motor sense they do not deny that there is something to be accounted for, and they account for it by the complexes derived from sensory elements. But these sensory elements differ in different circumstances. Therefore this debatable something which they endeavour to explain manifests

differentiations. And that is none the less true when we consider the analysis of the Mill school as insufficient, and when we account for the phenomena by giving its proper place to the Feeling of Effort.

The Feeling of Effort is, however, not itself well differentiated. It is the vague background on which on the one hand sensation is defined, and on the other hand Impulse.

When in desiring to see closely into these matters we propose to ourselves an exercise of Will, we are apt to think of the voluntary movements of the more massive muscles, and in this respect a certain sameness of circumstances seems inevitable. But Impulse applies to the function, or activity, of mind that carries the consciousness from one Immediate Presentation to another. Each resultant of mind is the starting-point to a new resultant in the movement of the mind, and the Impulse is the characteristic of that movement. Its differentiations are therefore appreciable.

To prevent misconception it may be noted that the fact that Feeling of Effort and Impulse are taken as Fundamental Processes does not imply that in all circumstances they can be appreciated as such. For instance, it is not implied that when a sensation of blue is noted the mind must have expressed consciousness also of a Feeling of Effort. All that is meant is that when the mind has consciousness of a state which we have called a Feeling of Effort, it is not possible to analyse this feeling into simpler elements, as Muensterberg proposes to do, but that the Feeling of Effort is fundamental. The appreciation of states of mind is largely a matter of subtlety of intellect and continued exercise of the faculties in that direction.

There is, however, in this regard nothing special in the cases of Feeling of Effort or of Impulse. We find

similar conditions in the case of sensation. Some persons have a much more delicate sense of differences of colours than others, and incessant practice may greatly develop the power of Discrimination in these matters. Moreover, as Helmholtz remarked, we habitually fail to see objects presented to our vision which if we directed our attention to them would be strikingly visible. And in the rapid mental movements of ordinary life we fail to observe with much Discrimination, or to remember, what we do see.

Now for the sake of clearness of exposition let us refer to the objective model. A stimulus affecting a sensory nerve may not produce a result in consciousness. If the stimulus be repeated, or its intensity be increased, we may reach a limit where an effect in consciousness follows. With some persons this may be reached much sooner than with others. Constant practice, attention, expectancy, freedom from distraction, all aid the Process of Discrimination.

When the sensation does arrive, it is Fundamental. All that we mean is that we cannot analyse it, or compose it; and it is no answer to this to say that under certain objective conditions of a similar character no sensation was apparent.

Now keeping this model in mind, it will be found not reasonable to reject the Feeling of Effort simply because any one may say, "I have a sensation, but cannot detect a Feeling of Effort."

There are occasions when those least sensitive to impressions, or those most recalcitrant to arguments of introspection, do experience something, even though confused in the mind, which contains a factor not further analysable, and which I have called the Feeling of Effort.

Similarly with Impulse, it is no answer to say that any particular individual, who has not given full consideration to the matter, fails to find any such process.

There are many positions, such as those of geometry, which are both true and fundamental, which require for their discovery a certain desire of knowledge and patience in its pursuit; and this is certainly true of Psychology.

Reverting now to the objective model, I say that just as stimulation of sensory nerve fibres is correlated to sensation, so we have at each instant a certain resultant of forces in the brain, and these serve to determine the new direction of outgoing nervous impulses. To this corresponds a certain mental phenomenon which I have called Impulse.[1]

The factors underlying Impulse seem to me very complex. They are not merely the complex of sensation with their associations, but the resultant of these playing on a great organised complex composed of all the previous experience, previous character of mind, all, in short, that composes the Ego. And all this must be conceived in a more vivid manner than that prescribed by Muensterberg's analysis. That a Fundamental Process should arise out of these complexes is not contrary to that which is admitted in other domains.

Sensation itself is not produced simply by the stimulation of a sensory nerve. The entire central nervous system is also a factor on the physical side. And, moreover, we may have the stimuli of several different sensations contributing to what we find in consciousness as a single unanalysable sensation, as when the vibrations corresponding to the whole spectrum give us, at length,

[1] What is called Action has been studied of late by many psychologists, including W. G. Smith, Judd, Alechsieff, Bergemann, and N. Ach. Cf. Ach's "Ueber den Willensakt und das Temperament. Eine experimentale Untersuchung" (1910). In another exposition, "Ueber die Willensthätigkeit und das Denken," Ach speaks of a fore, mid, and after period for the completion of a psychic effort. Here we are, as in the cases of Memory, Will, Attention, dealing with complexes. Analyse and translate into the terms here used all that is valid in these researches and they will be found to confirm the positions established in this treatise.

a sensation of white. Complex as is the constitution of the physical basis of this sensation, we can only know the result in consciousness as an Immediate Presentation.

Similar remarks apply on the motor side. It is not the flow of nervous energy along a motor nerve that corresponds to the Feeling of Effort in this case. The motor nerve is but a part of the complex physical apparatus involving also the central nervous system.

To those who say that such a process as Impulse is not discernible I would reply on similar lines to the arguments with regard to sensation. There is a limit at which the phenomenon is so far appreciable that in current language we talk of choice and Will. James Mill and Muensterberg set out to analyse this Will, but they at length, as will be seen in the whole course of the present chapter when read in connection with the preliminary chapter on Will, bring us to a conclusion that willing and not-willing are indistinguishable. And this would be so if the Fundamental Process of Impulse were non-existent. This is not the sole argument on which I ground Impulse. It is only a more or less objective demonstration offered to those who are unwilling to follow the previous arguments, and who refuse to find what I think can only be ascertained by subtle introspection.

Suppose now finally it be said: Why should not willing and non-willing be equivalent? What is there unreasonable in thinking that the mind does not determine its own course but only observe the process?

The paradox might indeed be forced upon us by adopting all the preceding exposition and by saying: Impulse is taken as the essential factor that makes Will different from the mere passive state of the play of feelings; but then Impulse, being one of the Fundamental Processes, is automatic, as they all are when the conditions are

given. Therefore ultimately Will, whether formed as Muensterberg would have it from complexes of sensations and ideas, or whether determined, as here asserted, by the incidence of something neglected in his analysis, yet is reduced to act under inevitable laws.

Here we come to what is perhaps the fount and origin of most of the discussions on this subject, the question of Free Will and Predestination (cf. pp. 579—589).

In order, however, to avoid all the mediæval nonsense that still clings to the subject, let us pose the problem, as that of ascertaining whether Will, as here set forth, is consistent with Determinism.

Scientists proceed on the assumption that the physical world is one entirely connected, inevitably inter-related whole. Thus if, as we might suppose possible without introducing any new elements, we knew all the forces operating on a body at a given time, we could determine its movement, and then successively its movements to the end of time. Extend this principle universally and we have Determinism.

Now if the physical structure be the correlative to the mental operation, we might say that given the external conditions and the physical structure the mental operation becomes inevitable. Conceivably it might be deduced and predicted. What then becomes of Freedom of Will?

But in the foregoing exposition, although the position of Will has been established, there has been no special consideration towards saving freedom of Will, if by freedom of Will be implied some action unconditioned by anything we know. An individual may exercise a choice, and the result may be in accordance with what was anticipated, but the choice may have been freely made.

It is not desired to evade the crux by any mere verbal escape. I will, therefore, express the matter differently.

Even accepting Determinism, may we not say that

amongst the factors that determine the resultant the Will itself must be included? It is not omnipotent, it is not unconditioned, it is limited in force and scope, but it exists.

Thus reverting to the former illustration, the small body perturbs the rest of the Universe. It has mass. It has weight, assuming for the moment that the law of gravitation is universal. We may eventually arrive at discovering by our analysis the conditions on which weight depends, but we cannot analyse it away. From the point of view then of the body we say that it perturbs the rest of the Universe as it moves.

But Determinism takes into account both the rest of the Universe and the body, and it finds all the movements determined. The assumption here is the constancy of the Universe. And if we interpret Determinism within the limits of our knowledge, the assumption is that the Universe is constant to our notions.

Now the individual in face of the Universe chooses—makes use of Will. That is feasible, and consistent with Determinism. But when Determinism embraces both the Universe and the individual, then the conditions of the choice, or of the Will, its whole scope, force, and operation are determined.

Previously we discovered the conditions of fallibility of our Reason. In this same larger scope we meet also with the conditions of the exercise of Will.

§ IV. Summary of Localisation and Will

Localisation and brain physiology generally are not directly of great help in psychological questions. The study, however, gives an air of erudition to conclusions possibly reached by faulty reasoning. Many physiologists have crude ideas of the meaning of localisation.

So have the idealists.

Broca's localisation, long thought infallible, is now abandoned. Examination of the psychological conditions shows that such a result might have been anticipated.

Will cannot be localised any more than Memory.

Broca's localisation is derived ultimately from Gall's crude suppositions.

The real meaning of localisation must be sought with regard to the elements of ideas and things, and in the process of development.

Bastian is nearest the present view.

It is maintained here that there is consciousness of efferent nervous activity; although high authorities may be cited for the opposite opinion.

High authorities may also be cited in support of this opinion.

The question is not to be decided by authority, but by consideration of the arguments that can be adduced.

Physiological Psychology is apt to be merely physiology plus Psychology.

Ernst Mach has struck out new lines of research in seeking for the deep bases of certain modes of mind.

No French work in Psychology hitherto has been sufficiently original and basic, though the French have supplied brilliant contributions of observation and suggestion. Condillac proposed problems similar to those here discussed, but his analysis was not convincing. A modern school of French psychologists are working in a scientific spirit.

Ribot and Binet consider that the declaration, "I will," indicates a state of affairs but adds nothing new.

Loeb, impatient of metaphysical doctrines of Will, is carried too far in the desire to reduce Will to ideation.

Loeb rides the theory of ions to death.

Muensterberg's system may be described as Fichte plus physiology.

Muensterberg's analysis is too destructive of Will, but, from Kantean sources, he holds to "Ethical Freedom."

Muensterberg may be cited for his position in regard to Unit, which is in accord with the principles of this present study.

Muensterberg is deceived in supposing that physiology gives any support to his theory of Will.

Muensterberg says that a reflex act does not become voluntary, but this, which is only true within limits, should be considered in wider relations.

Muensterberg's arguments that efferent impulses do not make themselves known in consciousness are not conclusive.

Muensterberg is right when he indicates that Will may be reduced to separate acts of volition; he is wrong when he describes these as merely formed by impressions, and representations derived from recollection.

Muensterberg misapprehends Darwinism, and uses an argument derived therefrom wrongly.

Muensterberg's analysis of Will leaves the action too automatic to be convincing.

Muensterberg's conclusion that there is no particular Will might be pressed to prove that there is no particular Ego.

The "Common Sense" view of Will must be explained, not explained away.

The Feeling of Effort is not the same as *Innervations-Gefühle*, as this term is usually employed.

The Feeling of Effort applies also to sensory nerves.

On the afferent side we have Sensation; on the efferent, Impulse; and these hold analogous relations to the Feeling of Effort.

The key to the position of Will is found in the study of Impulse.

The fount of all the confusion is that which lies in the question of Free Will and Predestination.

Freedom of Will is not inconsistent with Determinism if the factors of the Will be considered in relation to the rest of the Universe.

If the whole Universe, including the factors of the Will, be considered as the system, then all becomes merged in Determinism; but this may be interpreted in each individual case as implying only that the Will is conditioned.

CHAPTER VI

THE FEELING OF EFFORT

We have now reached a point where, after many tentative studies, we may consider to the best advantage the question of Feeling of Effort.

After the formulation of the Fundamental Processes (cf. p. 27), certain brief preliminary indications were offered (cf. pp. 27—35), and in the course of the exposition special chapters were devoted to the Conception of Unit (cf. pp. 86 *et seq.*), Memory (cf. pp. 234 *et seq.*), Association (cf. p. 523). Certain others of the Fundamental Processes, such as Immediate Presentation, conception of Time, conception of Space, seem to present no particular difficulty; or if difficulty be eventually discovered, the solution must be sought in recondite speculations not contained within the scope of the present work. I confess there is something alluring, and also baffling, in the thoughts that may be here suggested. In any case this book, as it stands, may possibly have done something to clear the approaches to various philosophic domains to which such considerations appear to lead.

Others of the Fundamental Processes, such as Agreement and Generalisation, have really been considered throughout the whole trend of the exposition. The Hedonic principle has been sufficiently set forth; and the principle of Negation does not require to be further expounded.

But with the Feeling of Effort and Impulse, in as far as bound up with it, the matter may be different. In an exposition of a subject like Psychology, so fundamental, and yet so intervolved with the whole web of experience, it is not possible to select each element, to define it separately, and to exhibit thence its combinations with others. And so it happens that although the term "Feeling of Effort" has been so often used in the foregoing exposition, it is by virtue of that exposition that we can now proceed to consider the reasons that seem to assure its very existence.

The chapter on Localisation has been helpful, because it has shown us the doubts or negations of celebrated authorities in physiology or Psychology. On the other hand, the position has been maintained by great thinkers. Little, however, is to be gained by weighing authority against authority, and still less by importing into the discussion any savour of forensic arguments. I do not indeed find the position overthrown by the objectors; but, on the other hand, I do not find it established by its upholders. None of the arguments advanced seem conclusive.

Thus, for example, Bain founds his opinion partly on the supposition that the nerve supply to the muscles is principally, if not entirely motor (cf. p. 662). Duchenne, who was a great physiologist, believed that he had discovered sensory nerves serving muscles (cf. p. 660). Wundt is in doubt on that score, but throws in his lot with Weber and Bain (cf. p. 664, and p. 668).

I am inclined to think that though Duchenne be right, the position of Weber is not greatly disturbed, for it must be noted that some sort of afferent impulse must come from the muscles, whether in part directly, as Duchenne maintained, or by those indirect means on the existence of which all are agreed—for example,

the cutaneous nerves, and the sensory nerves supplying the joints.

Such an argument as that which Bernhardt sought to derive from his experiments is fallacious (cf. p. 669). He endeavoured to produce muscular contraction without the process of motor innervation, and the means he employed was electricity. But the use of electricity introduces new disturbing conditions, and these may affect the delicacy of Discrimination which Bernhardt measured, and which he set up as a test. It is difficult to say, further, in how far innervation is excluded in such experiments. Various pronouncements of William James (cf. pp. 663, 668), Ferrier (cf pp. 662, 666, 668, 669), Schiff (cf. p. 670), and others have no great value beyond being expressions of opinion of authorities, and similar remarks seem to apply to others with whose conclusions I am in accord.

A. Bertrand, in "La Psychologie de l'Effort," attributes to Bichat the first expression of the theory of the "*sens musculaire.*" The genius of Bichat shone resplendently not only in his actual accomplishments, but in his very intuitions (cf. p. 399). In this particular regard, however, I would not care to attach high importance to Bichat's authority; for whereas psychologists unacquainted with natural science have often been inclined to wander in illusory regions, those who are for ever contemplating limited physical conditions often fall into errors of materialism conceived in mere nudity. Bichat thought, for example, that it was possible to localise the emotions, and he made the heart the seat of the warm affections (cf. pp. 625 *et seq.*).

Bell, the great English physiologist, shared the opinion of Bichat in the recognition of motor innervation; and in addition to the names of those, as Weber

and Bernhardt, who sought for clinical cases, or attempted to devise experiments, which should "isolate" this *Innervations-Gefühle*, we might cite Leyden, Helmholtz, Bernstein, Sternberg, Exner, and Beaunis.

One or two instances deserve to be noticed, if only to show how fallacious may be the interpretations of known phenomena. Helmholtz observed that if the external rectus, say of the right eye, be paralysed, then if the left eye be closed, and the patient attempt to look to the right, the external objects will appear to move to the right. The right eye in fact remains inmovable, but the sensations are similar to those formerly involved in the movement; and as the image falls upon the same part of the retina as before the attempted movement, the illusion is given that the external object has moved so as to bring about this correspondence.

Ferrier and William James offer the explanation that the left eye is moving owing to the innervation of the left internal rectus from the same centre as that of the right external rectus.. The sensations that seem to afford recognition of the innervation are really derived from the movement of the left eye. It should be noted that if the left eye be opened the illusion does not take place. This fact may be utilised by partisans on both sides, but it does not carry an effective argument for either. For in considering both theories in turn, it is evident that according to each we have simply the case of the fresher, changing impressions from the sound eye overriding those of the defective eye.

Wundt considered the experiment to be in favour of *Innervations-Gefühle*. Certainly the mechanism seems simple according to that explanation, but no conclusion should be drawn from such an argument. There is

more force, however, in his remark that if afferent sensations alone give us the impression of motor activity, there should be a close parallelism between sensation and contraction. This is far from being verified in cases of paralysis, or in other conditions where a great amount of conscious effort seems necessary to produce small effects of movement.

Sternberg hit upon a very ingenious device. He remarked that if the phalanges of the index finger be flexed at the first (that is to say, the metacarpal phalangeal) and middle joints, but the other fingers of the hand be completely extended, and the thumb abducted, it will be impossible, on account of anatomical conditions, to flex the index at the third (or distal) joint. But if the eyes be closed and the attempt be made, one will have the illusion that the finger has been flexed. In this case also it would be unjustified to assume that this motor innervation has been isolated, for there is involved as extensive innervation of muscles which are really in process of contraction.

Weir Mitchell has written interestingly on this subject, but I will make no further references at present to these researches, for his cases do not appear to me decisive. One of the most notable experiments of all is that of Beaunis. Struck with the force of the argument that part of the impressions were formed by the articular nerves involved—an argument which Westphal appears first to have advanced—Beaunis sought for a part of the body whose movements might be studied, and where such an objection could not arise. The larynx appeared to offer every advantage, for here also the experimenter was able to eliminate, by the use of cocaine, the sensations derived from the mucous membrane. Under these conditions he tested the accuracy of the notes of a

tenor singer, and he found that the precision of pitch was hardly altered.

But I think that we must be very cautious here in drawing conclusions. For if we compare this case with that of the man striking a blow at a punching machine, we shall find that we have here parallel conditions, though different senses are involved. The estimation of the effort in singing is aided by the sense of hearing. No doubt the sensations from the larynx help in the delicate adjustment required, but those who refer the sense of motor innervation to afferent impulses are not required to restrict these to the particular set of nerves most evidently involved.

One might be tempted to cite in favour of the opinions here held the instances set forth by Ferrier and by Muensterberg in support of the contrary view—viz. cases of definite motor activities with anæsthesia, and cases of attempts at movement though paralysis prevailed. These instances would be decisive, it seems to me, if the supposed conditions could be veritably ascertained, but it is difficult to say that with regard to all sensory impressions of any kind anæsthesia is complete (cf. p. 664).

Leaving these great names, therefore, I will endeavour to ascertain what it is really that inclines me to belief in the Feeling of Effort as a Fundamental Process.

In the first place the fact that various suppositions are made to account for mental phenomena affords, whether the explanations be right or wrong, grounds of belief in the existence, at least, of the phenomena. If one account for what others call the feeling of motor innervation, by saying, No, that is not due to a consciousness of the excitation of motor nerves, but, in a complex and somewhat obscured way, to the excitation of various sensory nerves; then the matter is resolved into a question of origins.

But in order to pose the problem better, suppose for a moment that we turned the tables on those who deny *Innervations-Gefühle* for motor nerves; that is to say, we declare: the motor nerves are alone involved in the consciousness of innervation; explanations quite as feasible as those considered on the other side can be built up on this hypothesis. Thus, for example, a person is sitting in his room in profound quiet at night. Suddenly a bell rings. He is startled even before he clearly realises the sensation of sound in its specific quality. But he might say: what has happened is that an impulse has reached the brain, and has then produced an explosion which finds outlet through various motor nerves, and the Feeling of Effort has arisen therefrom.

I say that on the face of it the position thus indicated is quite as feasible as that of the contrary as expressed by William James.[1] This, however, only implies the unsatisfactory character of our investigations at that level. Let us therefore make a clean sweep of suppositions, and again apply ourselves to realities.

For guidance of argument I say that I believe the Feeling of Effort is manifested both in sensory and in motor innervations.

Such an experience as that just described happened to myself, and I noted it carefully at the time. I believe

[1] This position is not put forward as a mere paradox. Factors from motor sources modify all our sensations. This observation has occurred to many who have studied attention, for though their attempt to build up a system by using complexes in place of elements is hopeless, yet many of their indications are of value when correctly interpreted. Ribot says of attention that its "constitutive elements" are motor. In a still wider application of the term attention M. L. Billings and J. F. Shepard studied this aspect of the subject: "Change of Heart Rate with Attention" (*Psych. Rev.* 1910). All this will be clear to those who have read patiently so far. The excitation of a sensory nerve is a necessary incident in sensation, but that stimulus impinges on a highly complex system, in the development of which have become implicated all manner of sensory and motor experiences and the combinations of these. If, beginning on the motor side, the matter were not correspondent with this, then the principle of development of the brain would incur a complication which seems unnecessary.

that the peculiar Feeling of Effort apart from the specific quality of the sensation was due to afferent innervation; because the quality of the Feeling seemed different. This is in fact the form of argument which alone we can adduce when we distinguish two sensations manifestly different. It is an application of our old instrument of introspection.

I notice, moreover, that when one touches an object which is too hot there is a feeling, a sensation, arising directly, and there is a feeling arising from the involuntary motor storm which is produced by our convulsive start. The feelings are capable of Discrimination.

It happened to me once when a young student to make experience in an intense degree of the Feeling of Effort in a motor storm. I was walking one evening with a lady in Melbourne when, it appears, a drunken man suddenly surged up and lurched near her. In her terror she screamed and convulsively clutched my arm. I happened to be absent-minded at the moment, and had not seen the man; so that the piercing shriek for help and the frantic clutch at my arm broke in on my senses all unprepared. I could not decide what to do, for I did not know what was happening. Yet in various directions motor impulses, tentative, uncertain, baffled, and futile, were being sent out with intense force and rapidity. From the neighbourhood of the whole length of my vertebra it seemed to me that a veritable escape of force proceeded in sudden disruptive clouds. So profound was the reverberation that there was with this an association of colour—grey. I made a note of the occurrence at the time (cf. pp. 55—62, and p. 511, also pp. 85, 95, and p. 527).

The association of colour impressions could, I think, only have resulted from the communication of various currents to the nerve strands, or at least the cerebral portion, usually involved when such colour impressions normally occur. There was also, no doubt, an implication

of various other sensory impressions such as those of touch in the regions most violently agitated by the motor efforts. Yet withal the main impression could not have been formed, I believe, by any combination of sensory impressions however intense.

Highly accentuated sensory impressions do not reach a pitch where they become confused with motor impressions; they seem to give way to sensations of pain. The two examples that have been noted are typical. In both cases the mind was unprepared. Sudden strong sensory stimulation was followed by motor impulses; but in the case of hearing the bell the sensory impressions seemed so far dominant that I believed that it was possible to observe a distinct Feeling of Effort associated with but not identical with the specific sensation; in the other case, the motor elements were predominant, and quite apart from any direction given to the motor impulses, or from any guidance of sensory impressions, I believe I observed a distinct Feeling of Effort in the motor discharge.

Consider again what is meant by intensity, especially in regard to those senses—sight and hearing—for which we can form a clear appreciation of the objective stimulus. Colour and pitch depend on wave length. Intensity and loudness depend on amplitude of vibration. The form of the wave may be determined by the superposition of simple wave structures. So that finally we see that the objective phenomena enable us to define the limits of variation of the subjective phenomena. When we have differences of colour the entire difference of subjective appreciation may be considered to be that of the sensations themselves in their specific character. But suppose we have two discs of the same colour, but one much brighter than the other, is the whole matter to be accounted for simply in terms of difference of specific sensations?

We speak of one colour or shade being more lively than another. Does not that refer to a recognition of Feeling of Effort purely on the sensory side? Or suppose that instead of a coloured disc we have a white disc, or a disc that gives an impression of lustre with as small an impression as possible of colour. Then if we increase the intensity of the effect, is there merely some change that can be summed up by reference to specific sensation and to the exclusion of a Feeling of Effort? It may be urged that even this Feeling is included in what we mean by the sensation; but even if it were recognised as something to be included the object of this particular argument would be gained.

For instance, I do not think we can conceive colour without form, or some manner of extensity, so that every visual sensation presents us with these factors; but though they are always associated we can readily make distinctions. We can vary the form and yet recognise that the colour is not altered.

It might be contended that if we had a square of red, and a circle of red of the same tint, and the same area, we have nevertheless two distinct sensations; and that is undoubtedly so; but we can form the Dis-association of the colour from the form in both cases; we can imagine the same square or circle of a different colour, as, for example, green, and we can form the Association of the two phenomena of red in a manner distinct from that of green. Can we then separate intensity from that? Yes, I think we can. We can even say that the intensity of illumination of a red disc is equivalent to that of a green disc.

The fact that we can speak of two shades of red, as being both red, or that we can speak of two discs of red and green as both being discs of different colours, implies something common in the midst of diversity. That

something common corresponds to the feeling of innervation of the nervous tissue corresponding. That feeling we may call, by definition, the Feeling of Effort.

These arguments are strengthened by the consideration of fatigue. Given the same objective stimulus the impressions are livelier to a fresh, active mind than to a mind affected by fatigue. The fatigue, moreover, in regard to sensory impressions is of a different character to that which follows excessive motor action. If a man, as for instance in a berth of a steamer near the screw, be compelled to listen to a loud monotonous sound, he experiences a sense of weariness or fatigue, even though apart from this sound he be in repose. The character of this fatigue is different to that produced by wielding a sledge-hammer.

Again if a man listen to a regularly repeated sound, as, for example, the ticking of a clock, he will find that now and then a beat seems to drop out. This may be in part due to fatigue of the actual sense, even though we account for the associated motor effects involved in directing the attention to the sound.

At least the effect is quite different to that experienced when some motor apparatus, such as a co-ordinated set of muscles, rapidly repeats some tiring movements until there is a pause necessitated by the need of recuperation.

When fatigue, as the result of prolonged exertion, is considered, a distinction seems possible between the fatigue of the senses which popularly we refer to as a surfeit, and the fatigue of the motor apparatus which we call exhaustion. In all these cases, however, it must be noted that the motor and sensory spheres are intimately associated. The languor or "neurasthenia" following a period of "over-tension" or "high pressure," may be partly due to excessive afferent stimulation, or partly to excessive

motor action, or to the deterioration produced by the lack of proper exercise,[1] or to changes in the constitution of various constituents of the body.

The case of shock involves too many obscure circumstances to afford us any decisive criterion. It may be said, however, that in cases of shock, involving motor effects mainly, as for instance in over-electrification either produced artificially or by means of a thunderstorm, there seems to be a distinct separation from cases where the senses are suddenly overwhelmed as by dazzling lights and deafening noises. The actual physical causes of shock, however, may not have a clear and direct relation either to motor or to sensory stimulation in excess. And even in those cases where the activity following the causes of shock has been mainly motor, how can we prove that the consequent feeling is not due to afferent stimulus—not necessarily referring to the "five senses"—occasioned by the altered conditions prevailing in the body?

The experience of mistaking the bar of aluminium for a bar of lead may possibly be explained without the necessity of supposing a knowledge, or feeling, of the storing up of energy. I do not mean to imply that such an explanation would be a good one, or the true one; but those who deny altogether the feeling of motor innervation might argue: the whole process of storing up the nervous energy necessary for motor activity is unconscious. All the impressions that our senses convey to us respecting an object, together with all that Memory holds respecting

[1] The following description due to Milton seems to show fine results of introspection, but it might apply either to sensory, or to motor, over-excitement:

"And every eye
Glar'd lightning, and shot forth pernicious fire,
Among the accurs'd, that withered all their strength,
And of their wonted spirits left them drain'd,
Exhausted, spiritless, afflicted, fall'n."

Paradise Lost, Bk. VI.

that object, produce in the mind certain judgments respecting it. The term "judgment" is here used in a wide sense, and does not imply the formal expression of a judgment, or even its specific recognition as a judgment. When therefore the intention is formed to lift an object, for example, a mechanism is set in work which prepares the necessary motor energy. But all this is unconscious. When the motor energy is discharged that act is also unconscious, and the feeling of surprise that may follow in a certain case is formed of combinations of unexpected sensory effects, and the secondary effects also of judgment in the new situation (cf. pp. 702, 703).

Here it may be conceded that there is a means of estimating the amount of the stored-up energy; but the means of estimation may not be by direct reference, it may be indirectly by reference to the sensory influences from the object and from various associations connected with it. Even if we think otherwise, how can we prove what we believe? How can we separate from all the complexity of our impressions some definite criterion as to the direct effect in consciousness of the nervous discharge along the motor nerves?

We see also that Weber's law does not help us. It is true that we can estimate so far as to say that one feeling of motor innervation seems to correspond to twice as much objective load as another. But the question is not thus settled. How do we know that this estimation is not really by means of combinations of sensory effects? Manual training, as for instance in the gradual refinement of the skill necessary to bowl a good ball, implies increasing accuracy of measuring the output of motor energy, and therefore of the amount stored up for the purpose of sudden release. But it does not seem possible to show definitely that the operation of storing up the energy may not be automatic and unconscious when the conditions

have been determined by the consensus of all the sensory elements involved.

Of course similar difficulties are presented to the upholders of contrary views.

In fatigue it seems to me that a means of determination may be found. Consider, for a moment, a simple case. A man delivers a blow at a "punching machine." He delivers it, let us say, with great force and accuracy and also with a certain joyous elasticity, which is a manifestation of the Hedonic principle. Suppose that he continues to punch until he is very tired. Then suppose him to rest for a time, and then to get ready to punch once more. Now the sensory impressions are not greatly altered, but there is a difference in the feeling of preparation of the necessary muscular effort, and a difference also in the feeling accompanying the delivery. Even here it might be said that, though the sensory nerves usually considered, those of sight particularly, are not greatly disturbed yet, the sensory nerves from the muscles are tired, and the feeling of fatigue is due to their changed condition. The condition itself may be produced by excess of waste products in the nervous apparatus.[1]

But since the fatigue affects the feeling of stored-up energy before these nerves are stimulated anew by the actual experience, the school that rejects "*Innervations-Gefühle*" would require to suppose that the amount of energy is estimated by tentative communications along the motor nerves and thence, by reflex, along the sensory nerves. Those who maintain *Innervations-Gefühle* might say that such tentative communications took place with direct intimation in consciousness, or at least that the

[1] Here certain researches of physiology are of distinct value. Bowditch has established that sensory nerves may function for long periods without perceptible fatigue: "Note on the Nature of Nerve Force" (*Journ. of Phys.* 1895) and "Nachweis der Unermüdlichkeit der Säugethiernerven" (*Dubois-Reymond's Archiv.* 1890)

storing-up of energy following sensory impressions was not unconscious.

Were the explanations of the sensory school susceptible of proof it would not seriously disturb, although it would modify the expression of the positions set forth in this exposition. The only difference would be that the Feeling of Effort on the motor side would be arrived at by a mechanism which might be contemplated as indirect, but which in its effects in consciousness gives no indication of that kind.

An argument which seems to me to have some force is the following: Bearing in mind, in regard to ordinary sensation, the dominant character of the central excitation; and considering also what has been said, in reference to localisation, that we should imagine not special centres or seats for powers and functions, but a wave of impulses passing through the brain and affecting certain strands and regions more than others according to the nature of the ideas and activities involved; we may now contemplate a case where motor activities occur as part of a sequence of associations.

For example, a man may fail to remember a figure of the lancers, but if he actually begin to dance then all the steps come back in turn. Or an actor may have forgotten a part which he used to play; but if he proceed to represent it on the stage he may remember it. Motor activities then may become part of a stored-up system of ideas forming associations with new presentations. Hence we may have these as part of the antecedent factors in forming the new instantaneous resultant of mind. I believe that the feeling is usually comprised in part of impressions from afferent nerves; but I also believe that, analogously, we have usually in sensation influences derived from motor sources. When there is a distinct movement of attention in regard to a sensation, then in

the adjustment of all the bodily conditions favourable, there is involved a complex of motor activities and also consequently of afferent and efferent impulses, even though there be no clear expression of these in consciousness (cf. p. 686 and p. 704). Endeavouring therefore to form a picture of the successive movement of the wave of central excitation, it seems at least simpler to suppose that just as the excitation of one central part is the correlative of an immediate effect in consciousness (sensation), so the excitation of a contiguous central part is the correlative of that effect in consciousness (motor feeling) which undoubtedly occurs.

Evidently the question is not one wherein a thinker can dogmatise with advantage to philosophy. After considering as carefully as possible all the arguments that I could find of great authorities *pro* and *contra*, I have been forced to think them all illusory; and I seem to come near a conclusion only in the consideration of fatigue, and of intensity, and of the impression formed in my mind by such arguments from Associations as here given and by the whole trend of this exposition, and in careful introspection, particularly of such exceptional experiences as I have related in this chapter.

It must be observed that if the question were decided only on one issue, it would by no means follow that the distinction could only apply to such a case. The supporters of the purely sensory theory deny the manifestation of *Innervations-Gefühle* altogether. If that *Innervations-Gefühle* could be distinctly proved in one case, then it would be safe to assume that it had its influence in other cases of motor activity where its presence had been claimed.

The most reasonable conclusion appears to me that, just as in the case of sensation the stimulus of the sensory nerve has been a necessary condition,

but the matter of ultimate importance is the effect upon the brain, and this effect might be observed though in a modified manner when the peripheral element has ceased to have function; so, on the motor side, the main factor is the central nervous activity which directs the motor output, but which can also be manifested when that output does not follow the normal course. Here at least we have an hypothesis which affords an explanation of all we have observed, which implies the simplest principle of development, and which is consistent with every circumstance.

If the reader fail to acquiesce in these arguments, or if he decide for the contrary hypothesis, the matter may not even then be disposed of. For it will doubtless be understood that the question demands the most careful and delicate introspection, and that before forming a judgment it is well to have the matter continually in mind over a lengthened period, and to test it in as great variety of circumstances as possible.

In this way many features at first obscure will become clearer, but with the very clearness of view the difficulty of the problem will become more and more evident.[1]

[1] In the course of the discussion so many references have been given that there is no need now greatly to amplify these. The following, however, will be found very interesting: "The Sense of Effort: An Objective Study," by Waller (*Brain*, 1891); also "Functional Attributes of the Cortex," by Waller (*Brain*, 1892). Angelo Mosso, in various writings; Mott (*Journ. of Phys.* 1894); Loeb (*Pflüger's Archiv*, xlvi.) and a number of others have worked at the matter on the physiological side. Sternberg's work is of especial interest: "Zur Lehre von den Vorstellungen über die Lage unserer Glieder" (*Pflüger's Archiv*, xxxvii.). The great psychologists, Wundt, Funke, Hermann, amongst many others, deal with the subject. In America E. C. Sandford and J. Dewey (*Phil. Rev.* 1897) have expounded the matter. Amongst those who have favoured the Sense of Motor Innervation, Maine de Biran was one of the first to call attention to the significance of the question. Of late writers, in addition to those mentioned, Sully, Fouillée, Marillier, accept the principle; while to the list of formidable names of those opposed may be added E. Peillaube and I. P. Nuel.

CHAPTER VII

GENERAL SUMMARY OF REASON

The whole of the preceding exposition may be regarded as an analysis of Reason. Therefore Reason might be defined as the continued combination of the Fundamental Processes of the mind so as to arrive at results in accordance with the conditions of the external world.

But such a definition requires to be expounded so that we may form a notion of the manner of such combinations. In view of the complexity of the matter that now arises we may have recourse to a graphic representation founded on the actual structure and constitution of the body and particularly of the nervous system.

Upon this system let a force impinge, and let it find a representation in consciousness, as, for example, a sensation. The sensation, if powerful enough, is accompanied by a Feeling of Effort.

The tendency is for a disturbance of the system to find an outlet in motor activity. The form of activity is determined by a recognisable Impulse accompanied by a Feeling of Effort.

This elementary scheme, however, is only to be regarded as an aid to exposition in an intricate subject, and we now proceed to consider it in more complex development.

Conceive then a system containing a vast number of forces mostly held in equilibrium. On this system impinge various forces of space, that is, of the external world, which form Immediate Presentations in consciousness. Even though capable of being expounded into a great complexity of separate factors, yet at each instant of Time the total of such impressions is summed up as a Unit. Its effect upon the system is continued after another Unit has made its impression. The internal forces of the system also, never in complete equilibrium, are producing various effects. At each instant of Time there is a resultant of all these. Certain impressions from without and from within may have no effect in consciousness. But a repetition of impressions or a strengthening of impressions formerly too weak to produce an effect may at length result in consciousness. An effect in consciousness has not only its specific character as an Immediate Presentation, for example a sensation, but it may be accompanied by a Feeling which is not identical with the specific character. It may be that this Feeling of Effort is not perceptible; but by repetition, or by increase of force, it may become perceptible. In that case it is Fundamental. Like external forces acting on the system tend to produce like effects, and the response of consciousness is affected by a recognition of Agreement. As, however, the recognition is made more manifest by an interruption of a movement, we find in that case the Negation of Agreement, and in general it is more convenient to speak of this process which we call Discrimination.

Though the mind recognises an Immediate Presentation as a Unit at each instant of Time, yet that Unit and a succeeding Unit are bound in an inevitable relation of which the mind has consciousness and the

term Association applies to all such relations. There are various factors on which the strength of such Associations depend. A strong factor is immediate succession, but a stronger factor may be derived from emotional accompaniments. Sensations may be accompanied by an Hedonic sense.

It may be that this is imperceptible until the sensation is frequently repeated; but, according to an analogy before used, it must be considered that with every sensation there is an Hedonic influence which, even if not perceptible, nevertheless affects the resultant in the mind. When the Hedonic sense is perceptible it is Fundamental.

A Unit once experienced may be revived by Memory, so as to have Associations, though less vivid than in the original experience, with other ideas; and Associations may take place between such ideas and Immediate Presentations. The fact of Agreement and of Association implies Generalisation as a Fundamental Process; and then inevitably arise also symbolisation and classification. Considering now the resultant of the system at each instant of Time, we find its direction marked by Impulse, accompanied by a Feeling of Effort when the resultant finds expression in direct and powerful muscular exertion. But as, when the intellectual life becomes more and more developed, there is found an increasing extent and freedom of Association of ideas, so in the outgoing Impulse there is found an increasing extent of combination of Impulses which have to the actual outcome in motor activity a relation analogous to that which ideas hold to actual experience. In this play of the mind each of the Fundamental Processes has its reverse or Negation.

Such is the general statement of the activity of the mind. If the statement appear somewhat colourless

and barren, the explanation lies in its generality. This implies no vagueness or incompleteness; on the contrary. And just as a general theorem in mathematics may appear at first more vague and less interesting than some special example, until at length it is seen in operation covering that example, and is then beheld as far more fecund and more powerful in influence than any of its special cases; so the true importance of this analysis of Reason will be found by reading it in the light of all the examples that have hitherto been given.

The natural operation of the Fundamental Processes themselves, in relation to actual experience, give rise to a great number of secondary positions; and we thus build up what we know as Ego, Will, Abstraction, Symbolisation and Generalisation and Classification in an extended sense; Fancy, Imagination, Speculation; Research and Discovery.

With regard to Research it has happened that we proceed by throwing out hypotheses, and hypotheses are really only the complex analogies of what in the simplest form is the Association proceeding from Agreement, possibly an erroneous Association due to the defects of our Discrimination.

Now the question of verification or testing these hypotheses is not dissimilar to that of verification in any set and determined problem. The great special factor of research is therefore the setting forth of good hypotheses.

The criterion of a good hypothesis may be thought difficult to define, for we cannot know that it is good until we verify it. Yet by deep study of the world we find in it certain correspondences, and regularities, "laws," which assure us that the true explanation of phenomena will eventually be something more simple,

more symmetrical, and more fecund of new suggestions and discoveries than our previous view afforded.

Observance of these principles makes the difference between a good hypothesis and a mere futile guess. As the first hypothesis may not be right we see that to the reasoning, or discovering, mind there arises the advantage of imagination, energy, order, of familiarity with the subject only to be attained by immersing the mind in its facts and relations. We see too the necessity of piercing deep in regard to the subject, and also the advantage of knowing facts and relations from other realms that may serve to offer explanations of difficulties.

Hence we arrive at a true test of specialisation which is not necessarily that of a restriction to formal limits set forth by others, or of the freedom of contiguous domains marked by others; but rather an exploration determined by the veritable nature of the problems themselves in relation to the qualities and acquirements of the investigating mind.

All these matters must be considered in the study of Reason. Even in the ordinary course of life, and apart from scientific inquiries, we find nevertheless the occasion for research, for the discovery of the unknown; for a good reasoner is not thought to be one who merely tests the arguments of others to prove or disprove their intrinsic consistency.

In the scientific realm we find also the paramount importance of the mastery of technique. This offers means of testing hypotheses which otherwise float in the mind as tentative and ill-defined. The actual testing offers new suggestions, and high technical skill will be found to have a valuable effect on energy and even on the true use of imagination.

Finally, all these principles will be seen to be vivified in actual experience, and it may be observed that every

exercise of Reason, from the closest criticism of argument to the most determined analysis of a problem, or from the casual almost automatic operations of the daily round of life to the subtle and airy imaginations of the thinker or the poet, are all expressible in terms of what have been here set forth as the Fundamental Processes.

If this be, however, an exposition of Reason, there still remains in the mind the desire to find the matter expressed in some succinct and tangible form. The problem becomes of extreme difficulty, for tangible here really means popular, and that word implies a certain looseness of expression and at the same time a principle of easy applicability. Succinctness implies great generality, but does not dispense with the need of exactitude. We must, therefore, attempt to hold within the limits of a definition some principle that will apply to the highest forms of scientific reasoning as well as to the most current modes of passage from one set of ideas to another. We must exclude mere aberrations, for otherwise the whole discussion becomes futile. But we cannot exclude false reasoning; for how is it possible in a mere definition to offer an infallible test of right or wrong ratiocination, and how can we remove from our purview so much that occupies our attention in debates of importance?

All these considerations show that the definition should be treated sympathetically, and that a certain latitude of language must be allowed. I will in the definition, therefore, speak of "facts," not necessarily implying that they are established truths, but taking this as a useful word more elastic than objects and more easily understood than any cumbrous phrase expressing relation of objects. The word "normal" will be used simply to exclude aberrations. It would not be well to refuse consideration to the errors, say, of the colour blind.

Such persons could reason quite intelligibly in their own company; and if it be objected that their conclusions would suffer from lack of Discrimination, the reply is that at a certain level we are all liable to that failure.

Therefore we say that a man may reason correctly, given defined conditions, or in regard to a certain environment, and may reason incorrectly when the conditions or the environment vary.

Finally, therefore, with all these provisos we may sum up by stating: Reason is the mode of mental activity which consists in proceeding from fact to related fact in accordance with the normal exercise of the mind and in conformity with the conditions of the environment considered.

THE FUNDAMENTAL PROCESSES CONSIDERED IN REGARD TO A DYNAMIC MODEL

Throughout the preceding exposition, though the necessity of the Fundamental Processes has been shown in each successive incident of the progress of the mind, yet it will gradually have become apparent that they are not similar or co-ordinate, or, as we may say in a manner to be understood, not all on the same footing.

It was well not to express this at the commencement, because we were introduced early to subtle notions and to a manner of exposition not familiar.

Now, however, we may take a review, and, for the sake of that illumination necessary to progress in Psychology, indicate at least certain features of distinction.

Time and Space, though inseparably bound up with such Immediate Presentations as Sensation, are yet something distinct. We gain the impression that they are conditions of the world in which we live. Certain philosophers have attempted to explain Time by means

of Space.[1] But this is futile. It is more feasible to explain certain aspects of Space by means of the intervention of Time, as we have seen in the analysis of Externality. Yet, withal, in their simplest modes Time and Space seem to be unanalysable.

The Hedonic principle, again, may not appear essential to the mere mechanism of reasoning. Certainly we cannot exclude it, for it is part of our world; and, as I once heard a philosopher say, after deep thought, in answer to a question of mine, "I believe in the necessity of the world." The Hedonic principle, while a necessary part of our mode of existence, may, however, be regarded as a boon of Nature; for it is the ultimate touchstone which shows us that a universal pessimist philosophy is false.

The principle of the Unit we saw also to be an inevitable condition of the mode of action of our mind: it is a Fundamental Process. But it is not a Fundamental Process in the sense that it is recognised by way of Immediate Presentation, but rather it is a necessity, discovered in analysis, of the limitation of our powers. This principle then stands on a plane different from that of Sensation. It is a condition of action, a condition,

[1] I take the following from J. M. Stewart's "Critical Exposition of Bergson's Philosophy" (1911):

"The idea of number, even of abstract number, implies the simple intuition of a multiplicity of parts or units exactly similar to each other. They must all, at first, be grasped as side by side, and then, by a synthesising act of mind, added together. It is in space that this juxtaposition of units takes place. All explicit counting, presumably, whether it be numeral or ordinal, involves the holding of a number of exactly similar units in one moment, in a 'now,' before the mind—*i.e.* it involves the idea of space."

From my own standpoint I will say that herein is involved a failure of analysis of counting, on which is based an incomprehensible argument of the relation of Time and Space; and from the standpoint of Bergsonians I would ask: Is it by such ratiocination, even if they themselves are content, that they can hope to bring the light to others? And do they appreciate the whole character of the movement of the mind by which a chasm of darkness is to be traversed by means of that psychic vehicle—*i.e.*?

again, not found at large in the structure of the objective world, but in the nature of our minds.

The Sense of Effort is essentially a part of mental movements correlated to the nervous activities involved in consciousness; therefore, as for instance when related to Sensation or to *Innervations-Gefühle*, we may take it as included in the whole psychic state corresponding. Certainly it has been necessary, for the purpose of our analysis, clearly to define it as a Fundamental Process, and to exhibit it in this character subsequently as an element of synthesis in building up the course of thought. But now, having before our eyes a dynamic model of the working of the mind, we may consider the Sense of Effort as an incident, though an inevitable incident, of mental operations.

The recognition of Agreement might also, for the purpose of simplifying the dynamic model, be included under the heading of Association as forming, in conjunction with a mode of Memory, a certain form of Association.

Negation occupies also a position not co-ordinate with that of any one of the other Fundamental Processes; for it applies to all, and in the dynamic model may be represented as the reversal of any action.

There is in this view now left to consider: Immediate Presentation, Memory, Association, Impulse, and Generalisation.

With the first four of these we can form an image of a mental process corresponding to the simplest dynamic model.

The Fundamental Process of Generalisation leads inevitably, as we have seen, to symbolisation and classification, and these faculties, playing on the whole of the diverse objective world, enable us to branch out from the simplest mental act (still using the dynamic

model) to the vastness of that complexity which forms our complete psychic life.

We are now in a position to reply to two questions of quite opposite tendencies which may possibly have been posed in the form of objections. The first would dwell on the character of the total world of thought—its complexity, heterogeneity, obscurity, lack of definition, as well as the exceeding vastness of the range and the diversities within any limited scope of that range; how is it possible to express all this in terms of a few Fundamental Processes?

The other would indicate the expectancy of finding something in the ultimate mechanism simpler than the display of our Fundamental Processes; for how otherwise do we deal so familiarly with Reason, and how do we express its forms so as to be intelligible to minds of no great development?

It would not be reasonable to say that these two tendencies contradict each other, and that the truth lies in the middle; that is merely a forensic-judicial way of settling questions.

Both the positions indicated contain a basis of truth. We have already seen how the vast whole of thought falls within the operation of these Fundamental Processes, the impression of complexity being given by syntheses of these processes in conjunction with the diversity of objects; and we have already replied to those who on a confused view of simple forms might consider the list of Fundamental Processes excessive.

But now again, in this manner of holding up a dynamic model and of regarding the Fundamental Processes as not being all on the same footing in that regard, we arrive at a clear appreciation not only of the difficulties but of the explanation.

In other words, just as in the exposition of Externality

we did not find Common Sense abolished, but simply rendered more and more perspicacious; and as in the consideration of Will we still paid respect to the indefeasible demands of Common Sense; even while in both cases doing no violence to the true doctrine of ideas, but illuminating it and rendering it both more consistent and more subtle; so here in dealing with Reason at large we may find a nexus between an Idealism imbued with the most exquisite delicacy of analysis and a Common Sense that sees essentials in the gross.

And in this view, and with all the provisos and conditions already mentioned, we repeat the definition already given: Reason is the mode of mental activity which consists in proceeding from fact to related fact in accordance with the normal exercise of the mind and in conformity with the conditions of the environment considered.

The task of Psychology, and ultimately of all science, consists in illuminating this statement, in exemplifying it in diverse instances and in all manner of combinations, in rendering its terms precise and showing the relation between the objects of its reference. Those accustomed to the methods of mathematics would express the matter as: Showing all the modes of application of the general proposition; the Evolutionist might say: Developing the basic phrase.

BOOK III

DEVELOPMENT

CHAPTER I

REFERENCE TO LOGIC AND CLASSIFICATION OF ERRORS

HAD Aristotle in his analysis reached down to the Fundamental Processes of the mind, then logic, as we have since known it, would probably never have been created. Aristotle's analysis, however, was faulty and meagre; and once the form of the syllogism became known and studied, it was inevitable that the subject should be developed even into the fantastic shapes that tease our brains in the text-books of logic.

No great thinker ever found logic of any real service. Two especially can be cited, each remarkable in his own way for extraordinary keenness and activity of intellect, who expressed themselves with impatience in regard to formal logic. These are Dean Swift and John Hunter; great original minds. It is in the domain of research, in the absence of suggestiveness or stimulation, that logic must confess its failure. In the more restricted field of the examination of the truth of propositions the question becomes more trivial. If a man cannot follow a well-reasoned consecutive argument unless the propositions be put into syllogistic form, then he will be incapable of putting them into this form himself.

No one reasons in syllogistic form, just as no one

reasons ordinarily in the terms and formulæ of symbolic logic. Certainly propositions can be expressed in the form of syllogism; and so can propositions of a remarkable kind be expressed in terms of symbolic logic; but these are special exercises, in the one case too barren, and in the other too abstruse, to be helpful in the ordinary conduct of the mind.

No man who has nurtured his mind on formal logic has ever produced anything on that account. There is a style of mere pedantry and futility in the argumentation of one who has studied greatly on these lines. Indeed nothing is commoner than to find faulty reasoning at the very threshold of logical expositions.

For example, in the syllogism:

All men are mortal.
Smith is a man,
Therefore Smith is mortal,

it is often argued that the last proposition is of necessity contained in the first, since it could not be said that all men are mortal without examining into the special case of Smith. But that may not be true.

To avoid long argument, suppose that we had the syllogism:

All men in the conciergerie will be guillotined to-morrow.
Smith is in the conciergerie,
Therefore Smith will be guillotined to-morrow.

Here we may have been able quite well to make the first statement without knowing of the existence of the third, or even of the existence of Smith in the second proposition. But when in another fashion we discover Smith, so as to be able to make the second statement, then the conclusion follows.

By help of a little adaptation, as by an intermediate form, we could show that similar reasoning would apply

to the first syllogism. And here it may be remarked, by the way, that the method of elucidation here exhibited does not itself depend on syllogistic forms, nor could it have been suggested by their study.

In fact, the syllogistic form has covered up the essential reality of the case. We may know that all men are mortal, because life depends on physical structures which are mutable, and which are so conditioned that the mutations that arise must at length cause decay. Smith has such a physical structure. Smith will decay.

It may be objected that here the reasoning is not inevitable. But in the examination of reasoning itself we have seen that even the most fundamental reasoning is not inevitable beyond the inevitability of the constancy of the world as known to us. And the lack of the inevitable, if such there be, accords better with the real condition of our knowledge than does the consistency of the empty forms of the syllogism.

When we examine into the syllogism in the manner here proposed, we find that, just as in the biological world since Darwin, we are impelled to seek a classification which is a true classification because it is the veritable exposition of the natural history of the subject.

In order to observe in how far we must seek realities in regard to the syllogism, let us contrast two examples.

In the first place we may say:

All B's are C's.
A is a B,
Therefore A is a C.

Here is a proposition which is formally true, but which does not educate the mind.

But suppose the syllogism ran:

All mammals are viviparous.
The Ornithorhyncus is a mammal,
Therefore the Ornithorhyncus is viviparous.

We observe at once that to establish the first proposition requires a profound acquaintance not only with the actual condition of the animal world, but also with the mode of evolution by which changes at various stages have been produced. Similarly with regard to the second proposition we must, while bearing in mind the previous knowledge, give due weight to the various factors that determine the place of a special example in a classification.

All this, which refers to a real chapter in the history of science, involves research, and the right conclusion which has destroyed the false assumptions indicated above has opened up clearer vistas in the wondrous realm of organic development. Here we are far from pedantic jugglings with syllogistic forms.

The syllogism never gave the power to detect the source of errors. Thus during the Middle Ages when the syllogism was held in honour the minds of men were subjugated by what we have here called Authoritative Association. This was a real disability of which in the foregoing exposition we have indicated the natural history. But those who encountered it thereupon allowed their reason to fall paralysed, and their conclusions, as for instance when they thought that they had refuted Columbus or Copernicus, were ridiculous.

An elaborate examination of logic according to the principles of this work would involve reducing all its forms, and all its examples of error, to terms of the Fundamental Processes. This would be tedious, and of doubtful utility, for in the variations of the syllogistic form or in the errors derived from the faults of any form we do not exhaust the subject; we do not thus discover all the sources because we do not enter into the veritable character of reasoning and the cause of possible failure.

A much more fertile field would be opened up in the proposal, disregarding formal logic altogether, to ascertain

such a classification of errors as would infallibly include them all. The research of this problem would lead beyond the scope of the present volume, but some of the principles involved may be here considered.

Bearing in mind the manner of progress of the mind from resultant to resultant along a path that determines the relations, we could represent every error as an error of association. Accordingly in the course of exposition we have met with examples of what have been called Impulsive Association, Repercussive Association, Authoritative Association, Involved Association, and Weak Particular Association.

Involved Association is where a, b, c, d, e, are present, and the effect e is attributed to a, b, c, which may have nothing to do with it. Thus in medicine various incantations have been used from time to time along with actual drugs, and the ℞ with which the physician announces his prescription is said to contain a corruption of the symbol of Jupiter whose aid was invoked. Now the patient, and probably the physician, during many centuries attached some healing virtue to the invocation or incantation, but this may usually have been without effect.

This form of error is really common, as may be seen from the pains taken by acute minds to avoid it. I remember a curious instance where a lecturer, exhibiting an apparatus for regulating the supply of chloroform to a patient, had two vessels painted red and blue respectively; he was careful to explain that the apparatus would work just the same if these were made blue and red respectively.

Weak Particular Association occurs where a Generalisation is known, but where some Association that really falls within its scope is not well remembered. An instance may be given thus. In searching for tubercle bacilli a suspected specimen is submitted to various

processes, including staining and washing with dilute sulphuric acid. The tubercle bacillus retains the stain in spite of the treatment with the sulphuric acid, and it is hence spoken of as "acid-fast." Now the bacillus of leprosy is also "acid-fast," but as it is rarely met with the student might at once conclude that a microscopic slide showing bacilli stained with carbol-fuchsin, and acid-fast, indicated tuberculosis. If the bacilli in question were really due to leprosy, the error might be described as due to Weak Particular Association.

It is evident in this case that we might say that if the fact respecting leprosy had been known, the error would have been due to failure of Memory in this particular respect. The error might even be referred to as due to what we have called Impulsive Association; or it might be ascribed to incomplete, or to Intricate Classification.

There is nothing contradictory in all this, and that fact well illustrates the inter-relation of the Fundamental Processes. If, for example, the classification had often been insisted upon with demonstrations in the laboratory, but the student had been unable to recall the facts, then the error might be conveniently ascribed to faulty Memory. But if a student of excellent Memory had not had his attention explicitly called to the chances of error, although in some other relation he had been made acquainted with the fact that the bacillus of leprosy was acid-fast, then it would be convenient to speak of the error as that of Weak Particular Association.

What we should seek for in the study of errors are those sources of error which may be eliminated or at least clearly indicated. Suppose, for example, that a public speaker should declare that a nation is great because its power is dreaded, and that he should also point out that its system of taxation is mainly indirect, and that he concluded therefore that the only road to

greatness must lie through indirect taxation; the proposition would seem questionable if not absurd. But if all this be said with a noble voice, with what is called eloquence, with forcible asseveration, and with a vast array of figures and instances, and if the conclusion be also stated in a manner to appeal to national pride, then it is possible that the argument may be deemed not only justifiable, but inevitable.

An examination of speeches of the kind, even in great assemblies, will often reveal the whole category here set forth of errors. Yet such is the effect of Authoritative Association, and such the difficulty of tracing the exact incidence say of Intricate Classification, that a mere refutation on formal lines might have small effect. In such a case the only feasible argument may be to show an instance where the conditions prevailed but the results were far from what was hoped for. As a matter of fact even this method is less in honour than that of contesting some particular position, or showing the falsity of figures that may be immaterial to the argument, and so gaining the effect of Repercussive Association.

The inter-relation of the Fundamental Processes makes it difficult to secure a classification of errors which shall at each step proceed by a well-marked principle of division; and as, moreover, the discussion of the entire subject, though useful, would lead beyond our present limits, I will content myself with general indications.

Failure of any of the Fundamental Processes must inevitably produce error when that Process is involved. But that is elementary. It does not seem elementary, however, when we are asked, for example, to recognise Agreement between two processes of treating surgical instruments, by heating and by immersing in carbolic acid. But if we make use of the symbol, Sterilisation,

then we are enabled to allow play for Association as a Fundamental Process.

This example suggests that in dealing with the question we may conveniently have present the graphic image of a system, subject to the impact of new forces, and at every moment presenting a new resultant.

A principle of division might also be suggested, as to whether the cause of failure were found in internal or external factors. But we must ask what in this case would be an external factor. It is true, for instance, that Memory might be abolished by a blow on the head. This might be thought of as an external factor. But an attack of apoplexy, or an embolus in the brain, might have similar effects. These might be called external factors. Finally any failure of the physical base might be called an external factor.

But the physical base is so far the correlative of the mental phenomena that given the physical base and the environment the mental phenomena may be considered thereby conditioned. Hence factors that at first sight seem indubitably internal have an external cause, as, for example, those giving rise to a Weak Particular Association.

Again, a person who is colour-blind sees a red object and confuses it with green. Here there is a failure of Immediate Presentation, but on the basis of this erroneous Presentation itself there may be no defect of ratiocination. The reason is shown in its faulty aspect by comparison with that of normal persons who, by distinguishing red, are enabled to form more precise classifications, and obtain a more extended accord of their ideas with the phenomena of external nature. The question becomes one of Discrimination.

But our very faculty of reason, we have found, depends on a limit of Discrimination, and in such a case Dis-

crimination is considered an internal factor. We must recognise, therefore, that though the distinction between internal and external factors may afford a principle of division for our classification, and may be practically useful, yet it is wholly conventional.

In this way we might make certain progress by regarding as external factors all those that produced faults of Presentation, or faults of Memory due to definable physical causes; or again in another series, faults of Symbolisation in the sense of misleading definitions and the like; and faults due to Authoritative Association; and faults due to lack of positive knowledge necessary in the circumstances of every case under consideration. Fatigue might be set down as an external factor. And limitation of Time in view of an extensive and intricate problem might be operative as a cause of faulty conclusion.

Errors arising from any of these categories are common; but they are not usually of the character which beset the minds of educated persons desirous of ascertaining the truth about some question under discussion. That errors are also common here need not surprise us when we consider how difficult it has been to avoid error even where the subject has been of a mathematical or mechanical kind, and where the minds employed upon it have been endowed with the most brilliant qualities, and where an ardent desire of truth has been the sole motive of research.

Of internal factors we might note Memory again, but where the causes of failure of Memory were not grossly obvious; faulty symbolisation, as for instance by reason of faulty classification, or want of knowledge due to the subtlety of the matter, or the difficulty in the subject itself of ascertaining necessary points of fact. In these Internal Factors we might include Authoritative Associa-

tion, as in the form where a work of ostensible analysis has been conceived in order to defend some position accepted as unassailable, or desirable to champion.

Viewed in this light also every other defect of Association not obviously due to gross material causes might be looked on as due to Internal factors.

These might be separately investigated. Examples would be shown, and these again might lead to suggestions for further division. Thus whereas in face of the multitude of possible errors it would be impracticable to tabulate them and trace them to their causes, we might in the manner suggested arrive at a classification which might demonstrably include all, and which would, moreover, indicate their causes clearly and in a rough estimation their relative practical frequency.

The classification of errors is not quite the same thing as the progress of criticism with regard to them so as to secure avoidance. The best discipline with regard to this is to form a classification with regard to every particular case; so that the question may be asked, and in so far as possible determined: What are the elements which are here necessary and sufficient in order that a certain indicated result may take place? That is but another form of the tracing out of associations to their expressions in laws. The more delicate the Discrimination, and at the same time the deeper and broader the Generalisation, the more fundamental becomes the law.

CHAPTER II

NOTE ON THE DEVELOPMENT OF PSYCHOLOGY

THERE is no lack of histories of Psychology. Acute thinkers have spent freely both time and toil in the effort to elucidate even minute details of ancient systems. It has been broadly said in this book that Aristotle is the pioneer in the subject, but philosophic historians have traced the origins of the study in Hindu writings, and in Greece itself Aristotle had many notable precursors.[1] But Aristotle appears to have been the first to seek, in an energetic scientific spirit, some directing principle in establishing the elements of the subject, and to formulate definitely certain "Categories" or modes of mental activity.

A great deal of research has been expended on the origin of these Categories; Tredelenburg arrived at the conclusion that Aristotle was guided in his course by the study of grammatical forms. Be that as it may, we find that Aristotle stands as the great landmark of Psychology in the ancient world; and though his supple and comprehensive mind did not prove equal to the entire immense task to which he applied it, yet even to us, the "heirs of the ages" in this respect, his method is full of instruction. He had at least a clear conception of

[1] Cf. Theodor Gomperz, "Greek Thinkers"; John Burnet, "Early Greek Philosophy"; Friedrich Ueberweg, "History of Philosophy"; J. E. Erdmann, "History of Philosophy."

the veritable character of the problem of Psychology, and all subsequent methods must consist in the rectification, in the rendering precise and accurate, and in the extending, of Aristotle's lines.

From Aristotle to Kant we seem to find little done in the sense of reverting to Aristotle's original principles with the intention of interpreting them with accuracy and rendering them fertile.

From Kant onward the mind is swamped with the number and complexity of ambitious systems, yet the veritable work of development lay, it seems to me, in the foundation of the matter, in the examination still subtler and closer of the categories, or what may be taken to represent them—in an analysis, in short, more keen and determined than that of Aristotle, and based on a deeper principle than that with which Kant contented himself.

At this stage, however, it may be well, so as to cover the subject in its broad aspects, to adopt a method different to that of historical narrative, and to attempt to throw the first lines of a classification of the kinds of speculations or systems of Psychology that have been set afoot in diverse countries by various thinkers of genius. It will possibly be convenient to establish the classification without elaborate discussion, and subsequently to indicate in what manner the work of any modern psychologist may find its place in this system.

The germinating principle of Aristotle may be briefly said to be that of the Categories. He is the founder of the (1) Psychology of the Categories, or of the Categorical Psychology. Kant, in as far as his psychological work is concerned, is a disciple of this school, and hence all his followers are included.

Locke's great work on Psychology was to clear the

ground of the over-growth of pompous forms and scarcely intelligible metaphysics with which the schoolmen had covered it. He was an amateur, the directness of whose methods alternately amused and scandalised the professors. His method was essentially that of an appeal to experience, to the reality of things; and consequently avoiding the term "sensational," which has other meanings and which does not cover the scope of Locke's work, we may speak of him as the great figure of the (2) Psychology of realism, or the Realistic Psychology.

Both the Common Sense school and the Idealists are disciples of Locke, though in developing his system they find themselves, by reason of limitations and failures on both sides, in opposite camps.

New lines were struck out by thinkers of whom Herbert Spencer is the most conspicuous, and who are notable especially in that, not confining their studies to the narrow grooves of their predecessors, but taking a wider survey of the field of knowledge, their minds show the impress of biological studies. The doctrine of Evolution was expounded by Herbert Spencer in regard to Psychology; but it will be found, I think, that in that sphere it is a corollary suggested by the study of the development of the underlying correlative physical structure.

It does not seem well, however, to call this school the Evolutionary school, because there are found here deeper incidents than the adoption of that formula, and, moreover, the so-called law of Evolution appears to me to be rather a tentative classification than a veritable unveiling of the process of Nature.

We might speak of (3) the Psychology based on biology, or the Biological Psychology.

In this school we might include all the physiologists

from Johannes Müller to Ferrier and onwards; all the students of natural history who have thought philosophically from Lamarck to Weissmann, from Darwin to Romanes, from Buffon to Ferrier or Hachet-Souplet; all those who have studied development in children or in the lower animals; all the psychiatrists, and all the neurologists who have interpreted their observations by Psychology. Bain, who can claim a sort of spiritual succession from Locke through John Mill, James Mill, and Hume, is yet one of those who make a bridge with the biological school, and who serve to show that there is no antagonism whatever in these diverse ways of threshing out the profound problems of Psychology.

Another school may be said to derive its inspiration from the science of mechanics in a manner analogous to that of the biological school from natural history; this is the school of which Weber deserves to be considered the founder. It may be called the (4) Psychology of scientific estimation, or the Experimental Psychology.

Fechner, who gave a great impulse to the study, has affinities through Leibnitz and Kepler with Raymond Lulli and the mystics, and ultimately with Pythagoras. One meets in him with speculations as extraordinary as those with which Berkeley at times surprises and disconcerts us, but by introducing measurements as exact as possible into the study he has rendered immense service to Psychology. Weber, who had strong associations with the biological school, is a forerunner in this respect of Fechner. A great number of eminent psychologists, Wundt, Ebbinghaus, Ribot, Binet, Muensterberg amongst them, have developed in various directions the work of which Weber and Fechner laid the base.

To enter into the history of the development of

Psychology, even in reference to important names, and to show their relations to the schools from which they take origin—all this involves a task that lies outside the present study; but possibly enough has been said to indicate not only that the subject may be embraced by means of classifications resting on deep principle, but also that thinkers of quite different schools may co-operate towards an elucidation of the subject.[1]

Confusion has hitherto arisen from the fact that early in the history of the study thinkers, whose outlook was too restricted and whose analysis within that scope was ineffective, attempted to build completely sufficing systems. The Germans have been the greatest sinners in this respect, for the genius that has shone so brilliantly in mathematics and in the physical sciences generally has wandered strangely in those regions where the tether of fact and the test of the results were less available.

What, for instance, should be the criterion of effective work in Psychology? Evidently, whether the view of Classification here offered be accepted or not, the answer may be formulated thus: In any valid new work in Psychology there should be exhibited some definite accretion of knowledge in the whole systematic up-building of science, such as might result from closer examination of old positions, or from experiments undertaken to elucidate some definite problem; or, if the work be concerned with the foundations of the subjects, some new mode of investigation should be established or the analysis should be deeper and truer than that which it proposes to replace. Further,

[1] A complete history would include on the physical side contributions from Bessel, Gauss, Gerling, Prazmowski, Bouguer, Masson, Arago, Herschel before Fechner; and on the biological side Johannes Müller, Dubois-Reymond, Helmholtz, Donders, Exner, Auerbach, von Kries amongst others.

the conclusions which flow consistently from the system adopted should themselves be true and capable of answering any test of their validity.

Kant based his system on a sort of conception, or internal vision, of a transcendental realm of things-in-themselves where Pure Reason merges into Will. But we know of things originally only by the Process of Immediate Presentation, and as their relations are conditioned by all the other Fundamental Processes, and as the phenomena due to things are in other ways also relative to other things which they affect, then we do not seem able veritably to form a conception of things-in-themselves.

Moreover, Kant's theory of Pure Reason has been built upon an assumption, that Reason, being a faculty which surpasses the immediate experience of the senses, should in its refined state be independent of the senses. But the whole tendency of the present analysis has been to show that Reason is not only limited by the scope of the senses, but it is brought into being by virtue of that limitation. Therefore Pure Reason apart from the Processes of the Mind dependent on the senses cannot exist.

Those who, in order to save the Kantean school, desire to overthrow this reasoning must do so by showing in what way, or at what step of the chain of consecutive argument, it is inconsistent with any universal truth. Such an inquirer would be led back inevitably to the Fundamental Processes, and the sole resource left would be to reject the mode of reasoning altogether and to find refuge in intuition, faith, or authority.

Again, we have seen that Will is a complex built of many factors. There can be no entity or simple quality, or serene faculty of the Will, apart from the Fundamental

Processes. Will is thus also dependent on the senses; moreover, in the ultimate analysis of Reason and Will there can be no equivalence of formation.

Consider again Kant's Categories: *Stambegriffe des Verstandes.*

Judgments		*Categories*
	I	
Universal Particular Singular	of Quality	Unity Plurality Totality
	II	
Affirmative Negative Infinitive	of Quality	Reality Negation Limitation
	III	
Categorical Hypothetical Disjunctive	of Relation	Inherence and Subsistence (Substance and Accident) Causality and Dependence (Cause and Effect) Community (Reciprocity)
	IV	
Problematic Assertoric Apodictic	of Modality	Possibility and Impossibility Existence and Non-existence Necessity and Contingency

If these Categories be studied by any one who has read the present work, the main thought arising will not be concerned with the correctness or otherwise of the categories, but simply with the fact that they are redundant, overlapping, and incomplete. That was indeed inevitable from the manner in which Kant obtained them, without proceeding upon any sure principle, or without seeking to apply any rigorous test that the series was both complete and exclusive.

We find reproduced in the categories the basis of all logic systems, in that they present us with modes in which it is possible for the mind to move, but which are

formed by permutations on certain scholastic forms, instead of flowing from the investigation of the manner in which the mind moves in its Fundamental Processes, and in accordance with the modes in which the whole organism of the thoughts becomes developed. It would be possible by applying the principles with which we have become acquainted to show the reduction of Kant's categories to terms of the Fundamental Processes, and thence to exhibit all the vices of classification which Kant's formulation contained.

A study of Kant's system could be made really illuminative, but in this case it should not stop merely at exhibiting the manner of developing the structure, nor even remain content with exposing its inconsistencies and its ultimate failure at the base; but it should pierce down to the very marrow of the subject, and show the genesis of these notions, arising not in the form of true Reason on ascertained data, but in the temperamental needs of a cloistered soul, dominated by the authority not only of old philosophers, especially the Stoics, but also by the character of the actual temporal institutions under which he lived.[1] Kant's intellectual expression of his philosophy is extremely involved, and perhaps—and here again is opened up a vista of another field of psychological research—his unquestionable authority has been derived in part from his want of clarity.[2]

Kant's whole fabric fails by virtue of assumptions which have arisen in a system of defective analysis. The

[1] Here indeed is indicated a new field of philosophic research, and one that might be applied not only to Kant but to all his successors and disciples from Fichte to Hegel and Carlyle. Given their mental characteristics, their physical conditions, their moral strivings, and their environment, their philosophies could be exhibited as inevitably developed according to certain lines, manifesting often individual limitations rather than basic truths.

[2] For that which is made clear fails to astonish, and hence ceases to excite admiration; but obscurity allows free rein to fancy and wonder.

argument of the "Kritik der Reinen Vernunft" proceeds not from fundamental principles in a desire to follow the truth simply, but from the thesis that the position of Pure Reason and Will must be defended.

It has been said of Kant that whereas previous philosophers made mind revolve round the objective world, he, like a new Copernicus, made the object revolve round mind. But in philosophy we must beware particularly of ambiguity and of rhetoric. In ambiguity lies fraud, an old legal maxim has it; and it may be said, in rhetoric lurks illusion. In the face of thinkers of higher authority than himself at that time Kant rose and declared: "There is no philosophy." Therefore he and his followers cannot impose on our thoughts the error of authoritative association. Kant's mind was not determinedly enough analytical, as we observe in fact from the very terms of the eulogy applied to him. We have seen that both mind and the object are necessary for an Immediate Presentation; and we can know of the external world only in this way. Schopenhauer, a disciple of Kant, contrasted the position of Fichte and Schelling, who maintained that the subject, or the mind, was everything, with that of the Eleatics, Spinoza, and the materialists, who referred everything to the object; and he concluded that for representation, or idea, both were necessary.

We have seen in the previous exposition how by pressing onward the analysis of the Idealists, and by giving the Common Sense school illumination, we may find a basis on which we may philosophically speak of the external world in fair accordance with ordinary language. Referring to physical science, we find that if there be but two objects A and B it amounts to the same thing to say that A turns around B, or B turns around A. The remark about ordinary language will also receive clear light if we bring to mind certain reflections of M.

Poincaré in "La Science et l'Hypothèse" (p. 141); for the brilliant mathematician, who is a philosopher also, has said, with that fine French *esprit* which often seems to lighten on a subject: "These two propositions, 'The earth turns,' and 'It is more convenient to suppose that the earth turns,' have one and the same meaning; there is nothing more in one than in the other."

Kant was deficient in physiological knowledge, and in those wider views of the organic world with which the works of Darwin and others have made us familiar. Hence Herbert Spencer, finding nothing in Kant that aided his system, was inclined to underrate the Königsberger. But Kant, though not particularly versed either in chemistry or in physics, propounded a system of development of the Universe which was both wonderfully bold and yet simple, and which in the main was adopted by Laplace, and interpreted according to more modern views by Helmholtz. It would be extraordinary indeed then if Kant had left no great permanent trace in the field to which he devoted the greater part of his time and which he regarded as particularly his own.

In Kant's Psychology will be found the position of the Unit, with the suggestion that he was wont to proceed from that position in his search for guidance towards his categories. This is not clearly expressed, for the peculiar cast of thought which led Kant to the search of things-in-themselves and to Pure Reason and Pure Will has intoxicated his whole style.

Kant's transcendentalism, again, should be interpreted by way of the subconscious factors which have been constantly referred to in the course of this exposition. We have observed that, given certain conditions, all our acts, even those that become manifested in consciousness, are determined without the process of that determination necessarily appearing in consciousness. Certainly we

are able to see to some extent in what way these subconscious factors have become evolved; and they are not to be found in the region of Pure Reason. But if Kant's Psychology be read again in the light of the Fundamental Processes, many grounds of reconciliation through language appropriately adapted will be found.

Kant's system had no useful development. His followers, such as Fichte and Schelling, pressed forward his Idealism, but without analysis, in a manner of vague glamour. Their reluctance to modern science affords sufficient comment on their efforts.

Carlyle's "Sartor Resartus" is built, as far as its philosophical groundwork is concerned, on conceptions arising from Fichte, and hence ultimately from Kant. It is capable of no valid expression that bears the light of criticism, and even Carlyle's humour and pathos, and the beauty of individual descriptions, and the power of depiction of states of the soul, cannot absolve it from the essential lack of verity.[1]

Schopenhauer has attained a great reputation as a philosopher, but for many reasons apart from appreciation of clear conceptions in understanding and cogency of thought. In his own day he was little esteemed, even by thinkers who, like himself, claimed Kant as their spiritual father, and the keenest efforts of his intellect and those which at length gave him fame were stimulated by his contempt of "official" philosophy.

In the psychological world Schopenhauer, though he declared that Fichte's Idealism deformed the work of the master, yet remained too narrowly Idealist himself. Like all the Kantean school, and in a manner not countenanced by Kant's example, Schopenhauer refused to

[1] Here again a new field of investigation is opened up, having reference not to the fund but to the form of philosophic thought. The peculiar structure, for instance, of "Sartor Resartus" gave full scope to Carlyle's matchless powers while concealing his inability for sustained consecutive reasoning.

broaden out so as to embrace all positive science within the scope of philosophy. Consequently, apart from his air of pessimism and the sarcastic manner of his sayings, which belong less to science than to literature, Schopenhauer has given us no new insight into Nature by which it is possible to build new developments.

In his famous doctrine of the World as Will and Representation (or Idea) he conducts his thoughts into that blind alley of Idealism which we have observed depends on inefficient analysis and really materialistic assumptions (cf. p. 557). This style infected his later works to such a degree that they became, like so many outgrowths of the old German philosophy, mere divagations, though certainly in his case, as also in the immortal "Sartor Resartus," brilliant divagations.

Schopenhauer's use of the term Will is peculiar, for he does not restrict it to that of Will consciously exercised. It refers also to the vague though powerful impulsions that even unconsciously may control our destiny. But in this there is no efficient analysis even of Will consciously expressed.

In the chapter on Will will be here found expressed in another form all that is valid in the suggestions of Schopenhauer as to the deeper meaning of Will, namely in the expression of certain factors, some recognised, some not recognised, which help to determine our actions, of which our consciously expressed Will is one resultant.

Turning to the Realistic school and to the Biological school we find the great figure of Locke dominating English Psychology till the period of Herbert Spencer. Locke's analysis had given us a good beginning. He cleared the field, and illuminated the paths. But the limitations of Locke have become evident. We have seen that a great part of the work of preparing the resultant that appears in any mental process is carried

on sub-consciously. Whence arises this sub-conscious activity?

Herbert Spencer, bringing to the subject a system of physiological and biological factors which Locke had not taken into account, supplied the answer. There had been many a good suggestion in the matter before Herbert Spencer, but it was he who best combined a grasp of biological principles with the keen and subtle faculty of analysis necessary for the combination of two studies which had been held distinct.

Between Locke and Spencer we have a series of thinkers of whom the most notable are Hume, distinguished rather as an acute critic, and Berkeley, a man of original genius, but with a brain still clouded by the vapours of mediæval disquisitions. There are a number of others, men of considerable mental energy, but over the whole of whose work is found the trail of insincerity They write as if they were intent on defending certain prejudices, or beliefs arising from various sources, rather than with the intention—and this alone should characterise a philosopher—of following the truth whithersoever it might lead.

Then we come to the Mills, both earnest and great men, but whose actual original contributions to the pure science of philosophy have not after all been very considerable. The analysis of Will by James Mill is a clearing of the ground that has been taken as the starting-point of what has been offered here as a more extensive analysis, just as Hartley's study of Association has been referred to in the preceding exposition, which has endeavoured to widen the scope of the subject.

The most notable work of John Stuart Mill in the domain of philosophy is his Logic, which has already been referred to. The reading of John Stuart Mill has always made the impression on me of a mind active

and energetic within its scope, working methodically and under a peculiar mental discipline, but limited in view, lacking subtlety, and deficient in that quality of scientific Imagination which we have previously discussed. In accordance also with the exposition of Association (cf. pp. 525 *et seq.*) we find in Mill's work the impress of temperament, high, sincere, intense, but rather narrow in range of sympathy.

Alexander Bain, who might be called a disciple of John Mill, displayed to a higher degree the veritable genius of the thinker. Few philosophers have possessed so great learning in their subject combined with such fine acumen. His work in the domain of Psychology is mainly eclectic in this way, and his works give an admirable exposition of what might be called the technique of the study.

The naturalistic tendencies of the school of Locke inevitably suggested the desire to find closer and closer correspondences with the general body of science, and particularly to adopt wherever possible the principle of accurate determination of phenomena. Hence the appearance of the Experimental school was merely a question of time and opportunity.

It has been said there is no science without measurement, but that is not the case.[1] Even in modern science such discoveries as that of Oersted of the influence of an electric current on a magnet did not depend on measurement; nor did the discovery of the combination of acids and bases to form new bodies with properties different from both; nor did the differentiation of the sensory and motor nerves; nor the description of the tubercle bacillus. A great body of valid psychological

[1] Lord Kelvin's words are: "I often say that if you can measure that of which you are speaking and express it by a number, you know something of your subject; but if you cannot measure it nor express it by a number, your knowledge is of a sorry kind and hardly satisfactory."

science has been elaborated without measurement. We know that it takes an appreciable time for a sensation to form, and that it persists an appreciable time after the removal of the external stimulus. Measurement adds nothing to our comprehension of that principle in itself.

Yet it is certain that if, wherever possible, accurate measurements be introduced in the study of phenomena, the results obtained at length acquire an importance far beyond that of the particular measurement. The first of those who attempted to express matters of Psychology by numerical relations expressed in the manner of formulæ appears to have been Fechner. Weber by the introduction of accurate measurements had already established a base at least on which the subject could be profitably discussed (cf. pp. 215 *et seq.*). To Wundt is greatly due the credit of making Experimental Psychology a definite part of the study of Psychology. Amongst his other inventions is that of a chronograph which measures time to one-five-thousandth of a second, and this has been of great service in estimating the speed of nervous reactions and the relations of stimuli of various kinds to the impression in consciousness.

The extension of Experimental Psychology has been perhaps the most notable feature of the study of the subject in Germany, and hence elsewhere in the world, in the latter part of the nineteenth century and at the present time. It has distinctively marked what might be called the modern treatment of the subject.

The question of the trend of Psychology in different countries has been investigated by a distinguished American philosopher, E. B. Titchener, who has himself greatly advanced the study of Psychology, and particularly of Experimental Psychology, in the United States. Mr. Titchener's method was simply to estimate quantitatively the articles in various fields of Psychology

which have appeared of recent years in the principal Psychological journals of Germany, France, and America. The method is of course neither comprehensive nor exact; but the broad results are probably correct and are in accord with what one gains from the impression the literature leaves on one who examines in more qualitative regard the most notable works. It would seem that the older school of German thinkers devotes relatively more time to psycho-physics than the later generation of students who are again turning to analytical studies by aid of introspection. In France there is very little psycho-physics, and new lines are being struck out in such fields as the study of children and in wider biological references. In the United States the psychology of perception is studied, and the scope of experiments is widely extended.

Various interesting developments of new themes have from time to time arisen, but a close examination will show these may be relegated to one or other of the classes which have been here indicated, and consequently that they do not form new basic works.

F. A. Trendelenburg, who has shown remarkable learning and research in Psychology, has recently put forward a theory of Motion being a sort of first principle, whence he adduces Time and Space, and finally *Zweck* (purposive end). From the analysis of Motion which we have considered this seems an untenable doctrine. Trendelenburg's suggestions have not found much favour.

Hermann Ulrici finds the cardinal principle of the mind in *Unterscheidende Tätigkeit*, but this is fairly well referred to the Fundamental Process of Discrimination. It will therefore be found to have its place in a true system, but not to possess the requirements of a sufficient base in itself.

Avenarius has departed from Kant towards Locke, and his "Kritik der reinen Erfahrung" has had considerable influence in psychological circles, particularly in Germany and the United States. F. Brentano, in his "Psychologie vom empirischen Standpunkte," has been influenced both by Kant and Schopenhauer though he departs from both. He finds feeling and willing to be fundamentally one.

A. Meinong, who has impressed himself as a force in Psychology, has struck out new lines in studying "objects of a higher order." Let us ask a question, for example: A tune having been transposed to another key, how is it that though the notes are different, we recognise the tune as the same? In dealing with problems of the sort Meinong has offered many acute suggestions and he has opened up an interesting world of speculation. Yet it seems to me that the whole matter is susceptible of lucid explanation only on the basis of the Fundamental Processes.

The output of Germany in recent times has been prolific; and a sort of national character has been formed in the products of this description, the qualities most in evidence being those of a solidity of plan, care and patience in investigation, and thoroughness within the scope prescribed.

Where, however, owing to the elusive nature of the problem itself, the application of such means is difficult, German intellect has not been so successful. G. E. Müller, who is a brilliant investigator with a great range of activity, has put forward a theory of Attention. This has been elaborated by Pilzecker. N. Lange has studied fluctuations of Attention. None of these, however, has analysed in such a way as to show the relation of Attention to the Fundamental Processes.

Ziehen, amidst daring speculations, asserts that there

are psychic factors which have no physical correlative. J. Petzoldt has affinities with Avenarius in regard to the "Philosophie der reinen Erfahrung." M. Drobisch, as far back as 1842, had insisted on scientific methods in Empirical Psychology. W. Heinrich has vigorously criticised all the great lights of Germany, and finds something wanting in Fechner, G. E. Müller, Pilzecker, Wundt, Lange, Külpe, Ziehen, and Exner. He is less dissatisfied with Avenarius. Heinrich himself has, however, been mystified by the problem of Attention.[1]

In Experimental Psychology and Biological Psychology Germany has not only held a leading place in regard to actual production, but has also established her position as the source and inspiration of much of the work done elsewhere. What has been called the "official" philosophy is, however, still dominated by the notions of the Kantean school, and we meet here also the characteristic defects of heaviness and want of lucidity.

The modern French thinkers have done wonderful work particularly within the scope of Biological Psychology, and in the application of Psychology to wider problems of philosophy. The qualities that we have been led to expect in French authors are those of freedom of treatment, brilliancy of insight, clearness of expression, suggestiveness and stimulation of ideas, and charm of style.[2] It must not be supposed, moreover, that these qualities exclude breadth of view and completeness of

[1] Ribot's book, "La Psychologie allemande contemporaine," though containing serious lacunæ, will be found very interesting. Max Dessoir's similar work (1897-1902) is more complete. It has been brought up to date, though summarised in his "Geschichte der neuren deutschen Psychologie" (1911).

[2] These qualities are found with their distinct psychologic value even in essays of pure science, as, for example, those of Poincaré, Painlevé, Picard, Bouasse, or Houllevigue. An admirable book in this regard, "De la Méthode dans les Sciences," should be read by psychologists, particularly as it contains a fine essay on the methods of Psychology by Th. Ribot.

study; there are too many French works of massive grandeur to attest to the contrary.

Renouvier, of an older generation, had taken the principle of Relation as the foundation of Psychology, and he had revised the categories; but on the whole I cannot think that his essays on neo-Kantism have been entirely successful.

Omitting many names of distinction and power I find myself attracted by that of Maine de Biran, or Biran as one of his fervent admirers prefers to call him. Biran was both learned and acute, but he was somewhat disconcerting in the facility with which he changed the direction and intent of his thoughts. The following citation indicates his most abiding purpose: "If we knew how the Will set our body in movement, we would know all."

To me he is especially interesting for his advocacy of the position that there is a manifestation in consciousness of motor innervation; but I do not find his arguments convincing. An account of Biran's philosophy will be found in a charming little book of A. Bertrand, "La Psychologie de l'Effort." We find the great Ampère here introduced in a character in which he is less known, that of psychologist.

The excellent work of H. E. Beaunis has already been referred to in the chapter on the Feeling of Effort (cf. p. 702). Special mention, however, should again be made of those studies, the nature of which is implied in the title, "Les Sensations Internes." The examination of the sources of information or impression in the mind, apart from the senses usually recognised, promises to be extraordinarily interesting, and Beaunis has shown a classification which, though criticised of late, forms a good basis on which to build. (Cf. pp. 24 and 72.)

A. Fouillée in 1893 opened up a new domain of speculation with his "La Psychologie des Idées-forces."

The guiding principle is that of the fundamentally active and formative character of the psychical. A notion of this kind seems insufficient to form the foundation of Psychology, and whatever is valid in these speculations of high suggestiveness will, I believe, be found indicated in the present exposition.

Guyau and Bergson have taken as the point of their departure the questioning of the fundamental character of time itself. They and Fouillée belong to a school of thought which sets itself at variance with certain Kantean dogmas, but which nevertheless one feels to be permeated with Kantean influence. We find therein, as so often in the history of philosophy, the desire to defend some thesis, or to champion some principle which has been caught at by reason of some temperamental affinity or by the obscure influences of generations of traditional teaching; all this, rather than the determined effort to pierce to the foundation of things and to discover solely in the accord with the being of Nature itself the cardinal positions on which to found. This is not the place to enter into detailed criticisms of any contemporary work of Psychology, but I would like to refer the reader to Bergson's dealing with the problem of Achilles and the tortoise and to ask him to compare it with the analysis here exhibited in the chapters on Motion and Infinity.

Boutroux, Le Bon, and Le Dantec have, in different directions, opened up new fields of speculation, stimulating, but perhaps more philosophic than derived closely from the study of Psychology in its technical aspects. At the opposite end of the domain we have a work of very distinct psychological importance, that of Jaques Passy on the Psychology of Odours. B. Pérez has turned happily to the study of children. Ribot and Binet have not only stimulated the study by their devotion and by their authority, but have added to our

knowledge both in Experimental and Biological Psychology; and remarkable work has been done by Delbœuf, Richet, Féré, Pierre Janet, Bernheim, Godfernaux, Arréat, Ribert, and Jamin. The great neurologists Charcot and Duchenne, to whom reference has been previously made, have shown important applications of their science to Psychology, and have directly and indirectly given rise to schools of active, zealous, but not always orthodox disciples. More recently some remarkable special studies have been due to French thinkers, notably the fine experimental work of B. Bourdon; work showing regard for systematic treatment by Vaschide, and Matisse, and Dr. Toulouse; a study of Memory by Sollier; of Fear by Richet and L. Dugas; Roisel on Substance; Victor Henri on Fatigue and on Tactile Sensibility; of Sadness and Joy by G. Dumas; of the Pathology of the Emotions by C. Féré; of the Sentiments by Rauh; of Mental Activity by Paulhan; while the questions of Time and Space and Infinity have been investigated in a different spirit from that of Guyau or Bergson by de la Rive, Lechalas, C. Dunan, F. Evellin, C. Horion ("Essai de synthèse évolutionniste ou moraliste"), and Couturat ("Mathematical Infinity"); and Nuel and Peillaube have again raised the question of the sense of motor innervation.

Yet in spite of its courage, its perspicacity, its free handling of science, its energy and zeal, French genius has not, I think, rendered the full account of its possibilities in the realm of Psychology.

Of late years I have noticed some fine work coming from Italian thinkers. Therein I discover new evidence of that wonderful modern Renaissance of the Italian spirit which I have found elsewhere shining so luminously in the domains of biology and of mathematics.

In the course of the exposition the names of Italian

psychologists, such as, for example, those of Ferrari, Lombroso, Forti, and Barrovecchio, have from time to time been met with. The question is worth asking, however, whether in regard to Italy as a whole any new line of research, or any decided set of the current of thought may be observable. R. Assagioli, himself one of the brilliant lights of the new generation, is of opinion that comparatively the greatest activity in psychological circles in Italy lies in the science of pedagogy. Certainly good work is being accomplished in this province not only by such eminent professors as S. de Sanctis and Sergi of Rome, and G. C. Ferrari of Bologna, but also by G. Francia, Pizzoli, by Assagioli himself, and many others hitherto less widely known.

It is difficult for one to form just views of the relative importance of thinkers in a foreign country whose work is still in most cases in a condition of ferment; but after a study of the actual products of Italy I should have been inclined to say that the greatest weight lay in the field of Biological Psychology, particularly in the subdivisions of physiological, pathological, and psychiatrical studies. Dr. Assagioli, in company with the distinguished professors, E. Morselli of Genoa, G. Villa of Pavia, and S. de Sanctis, has started a new psychological review, *Psiche*, which is destined to widen the realm of this science.

It is interesting to note in Italy the city of any distinguished thinker, for it will be found that each of the great centres has its distinctive character in science, and this we are right in attributing to the influence of its representative figure. There are three noted schools of Experimental Psychology in Italy: one in Turin, presided over by Angelo Mosso; one in Rome, which has taken also an anthropological cast from G. Sergi;

and one in Florence, of which the professor is F. de Sarlo. Amongst various notable activities de Sarlo has produced a scheme of classification having a general correspondence to that here offered. He is also the author of a doctrine of "psychic causality," which may be compared to that of Bergson's "Evolution créatrice." F. de Sarlo may be said to belong to the Wundt school, though he finds a greater barrier between Psychology and the physical sciences than do Wundt, or Höffding, or his Italian confrère, Masci. On this point R. Ardigo has affinities with de Sarlo. Angelo Mosso, who is nearer to Muensterberg, has not only done great work, as, for instance, in his studies on Fatigue with the ergograph, but he has been the source of inspiration to a pleiade of younger men. Of these M. L. Patrizi, of Modena, now professor of criminal anthropology in Turin, has distinguished himself by studies of vaso-motor mechanism, and in general in the investigation of cerebral conditions related to certain psychical states.

A. Tamburini, one of the pioneers of Experimental Psychology in Italy, hails from Modena also; and so does L. Griffini, noted for delicate experiments on the sense of taste. Amongst others who have done good work in the technical department of Experimental Psychology may be mentioned in addition Colucci of Naples, E. Patini, who is also distinguished in psychiatry, Aliotta, Bernardini, Tanzi, who has also experimented with monkeys in studies on the functions of the brain, and Guicciardi, who has been associated with Tanzi, and also with Cionini in studies on Memory. The Physiologists are particularly strong, for besides those already referred to we find a number of names of zealous and successful workers, Laschi, S. Baglioni, C. Besta, who is more particularly an histologist, G. Ferroglio,

L. Mattioli, who has studied the effects of hunger and cold; M. Zalla, who leans to the biological side, and who has observed hibernating animals; L. Luciani and G. Seppilli, who have studied brain-localisations; C. Pariani, noted for work on the regeneration of nerves; G. Mingazzini and E. Rossi, who have given special attention to aphasia.

In studies on the organs of sense the names are prominent of Angelucci, V. Berretoni, who has investigated optical illusions, M. Ponzo, Ottolenghi, and G. Bordoni-Uffreduzzi. The realm of Psychiatry has claimed the attention of G. Buccola, Amadei, and Tonnini, who has put forth a classification of delusions, Arnaldo, Riva, who has studied delusions, and Rasori, Ceni, Bianchi, and Piccinino, who have worked on Mania. Bianchi has also observed the effects of alcohol, and Battaglia those of haschisch. F. Veronese has studied sleep; A. Renda, memory; Bonatelli, the illusions of recollection; and Ferri, the maladies of memory. Of those who have written in a larger philosophic manner we find Lombroso, Sighele, G. Chiabra, G. Vignoli, whose province is comparative Psychology; L. Baroncini, C. Cantoni, who is a Kantean; M. Calderoni, who has studied the Psychology of Pikler; B. Spaventa, who has written on the relation of Italian to European psychology; Villa, whose work on "La Psicologia contemporania" is of great interest, and P. Mantegazza, well known as a popular writer.

A special study of no small interest and importance might be found in tracing out the causes that have led to the development of Psychology in certain countries. The great broad streams are found at present undoubtedly in Germany and France. In England there have arisen from time to time great souls, profound original thinkers, Locke and Herbert Spencer, for example; but

they have appeared out of the setting of their environment.

Something similar may be observed in regard to most of the sciences. The history of mathematical development would not have been essentially altered if it had depended on France and Germany alone. Yet here we find also the great figures of Napier, Newton, and Hamilton. Chemistry was at one time called the French science; during the last hundred years the Germans have achieved marvels. Yet we meet the names, in epoch-making works, of Boyle, Davy, Dalton, and Ramsay. The figure of Darwin dominates the biological domain, yet in its whole range and diversity that science exhibits the work greatly of French and German students.

Even countries which have an independent intellectual status may for the purposes of science be considered almost as extensions of France and Germany. In Switzerland, Flournoy and Claparède seem to exemplify the French spirit, while Heinrich impresses the German stamp upon Zürich. Belgium is susceptible to French influences. Holland, so brilliant in these later days in chemistry and biology and physics, has produced comparatively little for Psychology. In the Scandinavian countries Höffding has done magnificent work; but Norway, for example, has found no peer in Psychology for her great geometers, Abel and Sophus Lie. Báràny of Hungary has studied the physiological groundwork of the sense of hearing with Teutonic patience and skill; Ferenczi is a disciple of the Austrian Freud. Tokarsky, Kostyleff, Alechsieff, and Kiesow, and others of Russian extraction, seem Germanic in their methods; though others, Soukhanoff for example, have French affinities. Even the Japanese, who have of late been attracted to these studies, Motora, Takasu, Takakusu,

for example, have derived their impulsion directly from Germany, or indirectly through English associations.

The few names that Spain possesses in Psychology to set alongside of that of Ramon of Cajal in histology—I. A. Gomez, in the history of philosophy, V. Mercante in synæsthesia, J. Garcia del Mazo in studies of the psychic effects of atoxyl, Pi y Sunor in localisation, for example—appertain to French schools of thought.

One factor of great importance consists in the organisation of the universities; and this is well seen in Germany in cases where these centres of light have absorbed the genius of other races. Questions of freedom of thought, comparative exemption from political turmoil, the wealth of nations, the practical possibilities of life, the dominating standards in civic or social domains—all these, as well as the intrinsic qualities of races, must be considered as helping to form the intellectual product of peoples and states.

To American writers references have been perhaps too scanty in the course of this exposition. The main reason is that references to any authors whatsoever, numerous as they have been, are only incidental. The whole purport and scope of the work in its intrinsic character could have been exhibited without citation of authorities at all. Moreover, the figures of greatest note in the American world of Psychology—such as William James, for example—have put forward systems with which on important positions I find myself in disaccord.

American Psychology has derived its inspiration principally from Germany, and in spite of many divergences the impress of Kant is felt everywhere in its high official circles. I can find no American thinker who has set to himself the problem with

which this book is occupied. Nevertheless there is no country in which the fetters of hidebound authority have been cast aside so freely as in the United States, and it is stimulating to find in certain quarters the true American genius, the bold, original, energetic attack upon the problems of Psychology. Certain American names are already well known the world over, such as those of William James, Muensterberg, Jastrow, Baldwin, Scripture, Stanley Hall, Cattell, Ladd, and Titchener. Many others are associated with studies of delightful interest: James Ralph Jewell on the Psychology of Dreams; Porter on the Psychology of the English Sparrow; Willard S. Small on the Mental Processes of the Rat; I. M. Bentley with E. B. Titchener on Musical Beats; C. H. Sears on Rhythm; E. Murray on Tickling; F. R. Sturgis on various physiological studies; H. Gordon on Paradoxic Reflex; Dewey on Infant Psychology; Lewis M. Terman on Precocity; R. S. Woodworth on Racial Differences in Mental Traits; W. H. Pyle on Expectation; R. E. Doran on Epilepsy; B. S. Talmey on Woman; Sandford Bell on Love. Others have been mentioned in connection with special subjects.

One of the great figures of American Psychology, G. T. Ladd, writes thus of the Categories: "They are our own notions resulting from co-operation of imagination and judgment, concerning the ultimate and unanalysable forms of our existence and development."

Those who have studied the foregoing pages will be struck, in reading such a sentence, not so much with its correctness or incorrectness as with the involvement and confusion of thought and the impotency of the attack. For when the problem itself is presented in a manner so obscure it is not to be expected that

we will be led to the foundation by a veritable trenchant and exact analysis.

On the other hand a study of the *American Journal of Psychology* gives a new fillip to energy by the contact with bright, active, energetic minds, striking out new lines, and working resolutely and with genuine American directness upon a great variety of studies. As compared with other nations the Americans will be found particularly interested in the work of Biological Psychology and Experimental Psychology, and in problems of general philosophy which may be approached from a psychological standpoint. Binet has remarked, with truth, that all this product requires co-ordination, yet on the whole it would be difficult to find anything more encouraging than the spirited work in Psychology of certain of the American Universities.

Speaking broadly and with regard to the main factors, it will probably be found correct to say that in Germany the Kantean school is in the ascendant, in France and in Italy the Biological school, and in the United States the Experimental school. In England most of the work seems to come within the scope opened up by Locke. It is true the influence of Kant is powerful in the Universities, and that elsewhere Experiment and Biology find zealous adherents. But the experimentalists are less daring and original than the Americans, and the biologists, even those who work at the topography of the brain, are less inclined than in France to wander into philosophic realms. The neurologists who, like Ferrier, have sought to offer a psychological complement to their technical studies seem to have been the least successful.

I will not enter into a discussion of the present aspect of English Psychology, for that would lead too far. There is abundant evidence in England to-

day of great intellectual activity; and subtle disquisitions on a variety of interesting positions in Psychology are put forth prolifically; but I am not acquainted with any work that has a direct bearing on the main problem of the present book.[1]

What has remained to be done? The answer will arise out of the review of the field as indicated in the present chapter. It has been said, for example, that after Herbert Spencer's Principles of Psychology nothing has been left for future thinkers. As well might one have said that after the expositions of Lavoisier of the principle of conservation of mass, chemistry had become a sealed book. Lavoisier's work laid the foundation of modern chemistry, but subsequently Dalton propounded the atomic theory, and the science received an impetus which opened up a hundred branches of research, all leading to important discoveries.

In the classification of the schools of Psychology, and in the comments that have followed, it will be evident that a basic problem had been still left unsolved. There has been no necessity to approach this through the medium of the categories with the confusion that is involved therein, and the misleading associations of high authority.

It was necessary to strike out in a new direction. The study of Psychology, while developing in many directions and becoming expressed in these branches in clearer forms, seemed to me to lack the central scientific principle, which, when reached, by persistent analysis to the basis of all mental acts, would be capable then of application in exhibiting synthetically the development of the most complex forms, and, moreover, would serve to

[1] Ribot in 1907 published a book: "La Psychologie anglaise contemporaine." G. Cantecor, in an article in the *Revue philosophique*, 1911, finds the actual tendencies of English Psychology mainly in the works of Ward, Stout, and Sully.

construct a system in which the diverse branches of the study with their modern extensions would be seen in due relation.

Considerations of this kind helped to give form to the research of this Psychology of the Fundamental Processes of the mind.

CHAPTER III

INDICATIONS OF PROGRESS

THE test of the value of a new principle in science is fecundity. If, therefore, this conception of Psychology and the actual analysis be valid, there should arise a great diversity of applications. Certain of these will be suggested without difficulty.

In the first place the analysis will prepare the ground for reconciliations, even in regard to schools usually considered as directly antagonistic. In the chapters on Externality we have sought for a basis of reconciliation between the Idealists and the School of Common Sense. This has not been obtained on the basis of any compromise, or by obscuring the issue in ambiguity of expression, but rather by moving onward on both sides with regard to principles which are indubitably true.

On the other hand the principles of the Kantean school have been attacked by means of the comparison of their conclusions and those that have resulted from a rigorous analysis.

The contrast indicates the manner in which reconciliation is regarded. In each instance it is necessary to examine minutely the principles from which we proceed, and to reject all the assumptions and developments which do not respond to the criterion of being in accord with Nature. In this regard no examination can be too severe, no criticism too ruthless. That which is valid in each

may be saved and thenceforward shown in the true perspective of the development of science.

What I mean here is not quite the same thing as the eclecticism of Cousin; at least not with regard to the possibility of building up a system by means of such eclecticism. We have already seen the virtual impossibility of such a method in dealing with the question of Localisation and that of Feeling of Effort. We found there that, having the main problem presented in these various lights, it was necessary to dig to the ultimate foundations of knowledge in order to find a principle by which to interpret the phenomena observed. And such has been the guiding spirit of the whole book.

But having obtained these elementary lights they become a lamp to light our way through what seemed a labyrinth. I believe therefore that it would be possible to examine the whole of the work of the Kantean school, for example, by aid of the Fundamental Processes, and to throw light on its veritable meaning and import, by dissipating the peculiar hypnotic air that invests it all, by adapting the verbiage to terms of the Fundamental Processes, by seeking for realities and aiming at precision, by dealing sympathetically with all that is genuine in the effort to uncover the secrets of Nature, and by cutting away determinedly all the overgrowths of mere assumption, of homage to tradition, or of limitations of the personal man. At least I now seem to read Hegel and others of the Kantean school in a different light to that with which I first endeavoured to pierce the mystery. These men are the old alchemists of thought.

In order, however, to complete such a reconciliation we need a classification of the whole matter. A tentative classification has already been offered, based on the methods of the various important schools. The classification has been of service in enabling us to deal more

easily with a subject of great complexity. But the classification is not satisfactory. A biologist may for special purposes resort to the methods and apparatus of Experimental Psychology in order to determine a particular question. Moreover, even Locke himself was glad of the aid afforded by experiment. And on the other hand the results of the biologists and experimentalists are barren if they be not interpreted by the aid of enlightened analysis. The classification is, therefore, only conventional, though it has served a useful purpose.

The difficulty arises from the fact that the principles by which every manifestation of activity in the domain of Psychology can be explained are already expressible in terms of the Fundamental Processes. It is therefore not allowable for any one of the biological school to declare that his studies form the be-all and end-all of the matter, nor for Mr. Scripture, for example, to claim the development of Experiment as a New Psychology. These are really but methods towards the understanding of Psychology.

As indicating the trend towards classification I have noticed in the publications of different countries various suggestions towards systems. They are all, however, merely lists of methods. N. Vaschide, in the *Revue des Idées*, tabulated his classification according to the methods which he indicates as: (1) Psycho-physical; (2) Psycho-physiological; (3) Psycho-pathological; (4) of hypnotism; (5) of mental tests; (6) of enquêtes (collective inquiries); (7) of mental analysis.

G. Matisse finds this list meagre, and writing in the same excellent periodical he sets forth the following: (1) anatomical; (2) histological; (3) of comparative anatomy; (4) paleontological; (5) embryological; (6) physiological; (7) of comparative physiology; (8) zoological.

An examination of these two systems shows that that of Matisse falls entirely within the province of Biological Psychology; that of Vaschide mainly within the scope of Experimental Psychology, except for Mental Analysis, which may well cover the schools of Categorical Psychology and Realistic Psychology. These schemes of classification are useful, and the broader inclusions offered by the principle of methods show the advantage of grouping.[1]

Besides these there are a number of schemes of classification attached to eminent names such as Fechner, Helmholtz, Wundt, Ziehen, Arréat, Binet, P. Janet, de Sarlo, but no one of these systems is satisfactory.

The question of classification really involves that of the study of methods, but certain writers have considered the problem of methods separately. W. v. Bechterew has written on the methods of Objective Psychology. De Sanctis, in his study of methods, upholds the paramount importance of Introspection. F. Rauh has examined methods in the Psychology of Sentiments. The essay of Ribot in the work "De la Méthode dans les Sciences," though highly informative and stimulating to thought, is conceived in a manner of generality and is not greatly concerned with detail. Claparède has formulated a valuable plan of psychological methods.

The question of definitions arises in various forms in connection with the study of methods, but several psychologists have devoted special attention to this matter separately. Claparède has advocated the unification and fixation of psychological terminology. J. R. Angell, on behalf of the Committee of the American Psychological Association (in the year 1910), has furnished a Report on the standardising of procedure in experimental tests. A proposal of Ch. Henry to obtain

[1] Cf. A. Gilardin, "Considérations sur les divers systèmes de Psychologie."

measures of "intellectual and energetic capacities" really involves, as we have seen in the exposition, a consideration of the whole range of Psychology and of all science in relation to life.

Another aspect of psychological development—which, however, should be based on the previous considerations—is that of organisation. R. R. Gurley makes a proposal for a "Biological-empirical Psychology," which, though comprehensive in its own manner, does not, however, cover the whole field, nor indicate clearly the classifications that underlie it. A. Fischer has written on the organisation and the tasks of psychological institutes, but we are in search now of a solution of a more extensive problem. E. Bartel has offered suggestions towards a survey apparently still wider in an essay on the systematisation of all science, though it will be found eventually that these problems, whether they be regarded first from the standpoint of the positive sciences or from that of Psychology, are inevitably linked together. C. Richet, R. Meunier, and J. Lindsay all look hopefully to a higher spiritual region of Psychology.

If now the import of this whole exposition has been fairly seized, it will be possible to regard with real appreciation two tendencies of quite opposite characters. P. J. Möbius published in 1907 a work, "Die Hoffnungslosigkeit aller Psychologie" (The Hopelessness of all Psychology). This was not the querulous complaint of an ignoramus or a dilettante; it was the expression of the Faust-like disappointment of a man of Faust-like learning, though learning based too largely in regard to Psychology on the system of Kant. That hopelessness should be the result of such learning was inevitable, for hopelessness was already imported into it when it was conceived that a system could be formed which

did not build at the broadest and deepest base accessible to us—that is to say, on the Fundamental Processes—and which did not proceed step by step according to methods of the utmost rigour. It is nobler, speaking at large, to create than to search, but not in beholding the Universe. A Creator has already done the work, and we are not behind the scenes.

When a sense of the hopelessness of the old metaphysical conceptions strikes a mind less trammelled with learning but more endowed with the energy of a resourceful people, the tendency is to demand an outlet. Accordingly we find an American writer, S. F. MacLennan, in the *Psychological Review*, calling out for "organisation" in Psychology; that is, for the production of something that will not only show the interrelation of parts but also direct the study towards a definite "climax," or at least to definite separate ends.

From all these considerations there arises in my mind a suggestion of this sort: I believe the Fundamental Processes must be in future the basis of all work in Psychology. Then with regard to classification it will be useful to take the principle of method, but this need not necessarily be that which I have already tentatively adopted founded on the methods that have been notable in the actual historical development of Psychology. It might be better to devise some new scheme of methods, first with broad basis, then by successive divisions indicating in order such methods as those mentioned by Vaschide and Matisse, and also other methods that may be suggested.

All this I should like to see exhibited on a large chart, which must not be conceived as necessarily in one plane or surface, the methods being associated with the names of workers in bold relief, and with brief but significant guiding rubrics and legends with dates

and reference to works. The legends should point out only veritable original work that has contributed definitely to the progress of the science. In this way we should find exhibited the history, the course of development of the science, and of the study of individual positions, the actual state of the science, the means at our disposal, the inter-relation of studies, the value of any effort in the perspective of the acquired knowledge, and the significance of the whole.

However, I would not care to stop there, for I believe that this step would lead to the next, which would at length relegate such a work simply to the purposes of reference and to the glories of a past régime. For a clear survey of the whole domain would indicate that the study, like that of elementary mathematics, must be rescued from the huge tangle of its historical development and be shown, as based on Nature, according to its own natural evolution. The final stage in that respect will be reached when the teaching becomes didactic or dogmatic, though of course with a clear path left open and the way indicated to those considerations which have allowed the basis to become established.

Here then we have found a framework for all the diverse activities which are now being manifested in the study of Psychology, and we have set before us a determinate purpose. The process will by no means end there, but the place has now been reached where certain special studies may be indicated as serving to complete the system projected.

Referring to the Fundamental Processes we may ask in what manner we receive suggestions from their consideration separately.

Immediate Presentations are concerned not only with the five senses and within the range ordinarily considered, but with any mental impressions which arise not through

combination of other impressions but in their own character.

We have noted the sensations of pain, and of heat, and of cold, as distinct, and we have seen that certain measurements relative to these have been undertaken. There is still with regard not only to these, but also to all senses, opportunity for original work in precise determinations.[1]

But we have to deal with other real but more obscure sources of sensation (cf. pp. 24, 72, 754). The whole field of these should be examined. They should be estimated as clearly and accurately as possible, and exhibited conspicuously as factors of our mental states. The classification of Beaunis might be taken provisionally as the basis of special investigations, while in another field, the paths indicated by Hachet-Souplet, there are shown vast possibilities of comparative studies.

Then we have the field of the emotions, which should be examined to find in how far they can be analysed, and to what extent they rest on the basis of Immediate Presentation. Godfernaux and Rauh in France have studied the sentiments from different points of view. Féré's "Pathologie des Emotions" opens up a domain which may be extended into the entire realm of Psychiatry.

The Unit suggests the need of determinations of the rapidity of formations of impressions, and of their succession. A good deal of work in simple cases has been done in Experimental Psychology on these lines; but there is place both for ingenuity in devising new experiments and patience in carrying them out.

The study of Association is attractive, and the method that has been indicated with regard to the examination of Shakespeare's works could be carried out not only

[1] In regard to thermic conditions Herzen, Goldscheider, and Donaldson have already done excellent work.

in literature, but in various philosophic works ostensibly more scientific. Thus we could see the work in relation to the mind that formed it, and we would have a clearer appreciation both of its strength and of its limitations. The whole region may be expanded so as to deal, for instance, with the effect of temperament and environment upon work usually regarded as entirely intellectual and objective (cf. p. 53).

Special studies of associative power of different senses offer scope for experimental work. An interesting paper on the Associative Power of Odours by J. W. Harris in the *American Journal of Psychology* awakens expectation of further research.[1]

The study of Agreement, or its obverse, Discrimination, suggests measures of the fineness to which separate faculties may be trained by persistent exercise. These considerations also lead on the one hand to histological work, and on the other to the examination and development of our instruments of research. Histological work is required to determine, if possible, the limits of Discrimination, as, for instance, implied in the actual constitution of the hearing apparatus, or that of the visual apparatus. The terminations of the optic nerve, and their relations to the rods and cones in the retina, contain mysteries of which we may yet become the masters.

Various instruments are used in the task of rendering our psychological knowledge more precise, and whether these be chronographs for measuring the rates of reactions of processes, or microscopes for increasing the range of our vision, their improvement will be not without influence in psychological science.

Memory has already been considered. In this field a

[1] Dr. William Elder, in a lecture on the Physical Basis of Memory, has some suggestive remarks on the associations of the odour of pine trees.

good deal may be done in regard to strengthening not by artificial aids, although these may be useful at times, but by considering attentively the conditions on which Memory depends and improving any of those which are under our control.

Generalisation, with its expressions in Classification and Symbolisation, will be referred to later.

The Feeling of Effort deserves renewed study. We have seen in what way it has aided us to the analysis of Externality. We have here factors involved susceptible of measurement. The complete understanding of all that is implied in the Feeling of Effort would clear up many obscure points even in the appreciation of the æsthetic arts.[1]

The study of Impulse aided in the analysis of Will. Cultivation of the Will is a matter for scientific investigation, and we have here a field in which there is scope for much good work.

The Hedonic principle should not only be studied closely in regard to simple sensations of the separate senses, but also in combinations of these. There is here a field of experiments in the search of some correspondence to Weber's results.

The relations of Time and Space give us, amongst other things, the whole scope of mathematics. There seem, moreover, to be mysteries in the intrinsic character of these processes as presented to us, and possibly a sustained scrutiny will make the questions clearer.

But when we consider the combinations of the Fundamental Processes our view becomes enlarged. Psychology should not be looked upon as a science, or an interest, apart from the positive sciences, or

[1] A great deal of attention has recently been devoted in Germany and the United States to a subject which has connections with this, that of Rhythms, Clangs, and Metres. The learned work of F. B. Gummère on "The Beginnings of Poetry" may be profitably consulted also.

any other domain of mental activity. It is often so considered, and the specialists of other sciences usually take small note of it, or regard it merely as a kind of curious subject of culture, wherein speculative minds may find diversion from studies of realities. Those who place a higher value upon it, and feel its peculiar fascination, even those who adopt the designation "the science of sciences," may ascribe to that phrase the meaning rather of the best, or the finest, of the sciences, just as one might say a poem of poems. But that is not the position here laid down. Psychology is the science of the sciences in the sense that the sciences are parts of its discipline or duty. It includes them and forms them.[1]

We have already noticed the similarity of the Processes in different sciences. But this principle must also be brought out more strikingly. The Fundamental Processes and their combinations form the whole schema of knowledge. All that we know is represented by this schema and the objects that illustrate it. We use here the term "objects" with the widest meaning. And just as an engineer could design and classify, even before construction, all possible forms of girder-bridges, so here in this wider scope it would be possible to indicate the schema of all that we could know. Our actual knowledge would be seen to depend on our experience.

[1] Here is suggested a corollary which will at length produce a revolution in education, or, at least, a displacement of its centre of gravity. What is intended is not merely a more rapid approach to the great sciences, and a comprehension of their laws, their methods, and their main results, but also that the volume of science should bulk more largely in the perspective of our intellectual domain, and that the modes of the sciences should become to us both familiar and inspiring. What classical learning was to the Renaissance, such should science with its higher import be to the modern world, and no less should be the enthusiasm of its study. A new birth of literature and art would ensue, and finer forms would be developed. And man's position would be improved in regard to that domination of the forces of Nature which is his task and destiny.

Psychology, properly understood, is not something overlaid upon science, but is the stem from which its branchings proceed.

Thus an electrician seeking for the cause of some bad working in a dynamo, and a physician auscultating a patient's chest, deal with different objects. By virtue of the character of their professions their whole relations in the world of things and in society are different, and in their studies they have unequally developed the parts that may be found in both; yet here their processes may be expressed in general terms in a manner of correspondence, and even where they differ, that also could be analysed until in the analysis the components would be seen to be similar although variously combined.

Such studies as those of Meinong on "Objects of a Higher Order" will be seen to be capable of a general expression and a systematised investigation. We are here in presence of combinations of the Fundamental Processes of such a character as to be capable of being set forth as types.

We have certain of these syntheses already expressed in our language, but such syntheses have often been formed in confusion of ideas. What is necessary therefore is to explain terms already in use by the light of Psychology, and to adopt or create where needful special terms for special purposes. We proceed in this way in a manner of which the best exemplification is shown in mathematics; by forming a commencement at a level where propositions are, if not certain, at least certainly accepted, and then in the course of experience combining according to our accepted principles, and obtaining positions—formulæ or constructions—which we indicate by our symbolisation.

Holding this principle clearly in view, therefore, we

see that all that we know may be shown to be based on the simplest experience in accordance with our Fundamental Principles; and that in all that we express we may discover what assumptions still stand in need of analysis to that basis. When the principle has been clearly grasped that Psychology is an organic part of all science, and when a standard system of study has been set up on this basis, this may be modified according to the experience of particular cases.[1]

These considerations bring us to the suggestion of a science of education of the mental faculties in which the field of exercise should be that of education in the sciences. In the more simple physical exercises we see that our training in gymnastics serves as a good foundation for a great variety of other exercises; and it would be possible in theory to classify all the postures of the body, and to strengthen the parts in adaptation to these so as to meet any contingency that might arise in other exercises. This is not practically feasible, nor is it necessary. We strengthen the systems, muscular and others, of the body generally, and in our exercise we instil into the mind or into the body of the athlete the principles of combinations, so that at every turn he may adapt and improvise.

To train the mind on the schema of its possible combinations would be like teaching the grammar of a language without its literature. We have to consider a number of factors, and one of these is the stimulus that the learner may feel in his studies. It is unscientific to ignore this factor (cf. pp. 520 *et seq.*). But the teacher

[1] Recently Dr. Hans Much of Wurzburg in writing on such a technical subject as Immunity (Die Immunitätswissenschaft) began with references to the Idealism of Plato and of Kant, and treated the "shallow" philosophy of Aristotle with scorn. The critics laughed at all this in a work on Immunity; but, while differing with Dr. Much in regard to his appreciations, I find here something which should be present at least in the minds of all scientific men.

who adapts his system to various needs should himself know the grammar, and should conduct his lessons with that knowledge always in mind.

Similarly with regard to Psychology, we have a natural development of the subject and we have a natural development of the mind of the learner; and we have also various forms in which the development of a science could be illustrated. We must consider all these factors, but always with the comprehension of the manner in which Psychology underlies the study.

In the old days, and even often nowadays, a man might say, "I know nothing of Physiology, I am a specialist in Psychology," and consistently with his notions of Psychology he might esteem one very ignorant who could not quote Plotinus on Beauty, or cite elaborate arguments of the Scottish philosophers on matters of ontology. Or again an electrician might say he knew nothing of the applications of electricity to Experimental Psychology or even to the theory of Ions. But he would consider another hardly within the pale who was ignorant of plating work or of segregating gold from gangue by the electro-magnet.

The notion of specialism, we may observe, arises to some extent from commercial considerations, and also from the influence of teachers in the sense of marking their own limitations. But if we say that a specialism should include all that has a bearing on the understanding of the subject and also on the clear view of its applications, then as we have abundantly noted we must in regard to any science know at least the main guiding principles of allied sciences. Here we are confronted with many difficulties. Science is vast; mind limited. Having in view scientific and philosophic education we would save resources by throwing over a number of cumbersome studies which with little

profit absorb time and energy. We should then improve the methods of teaching the sciences themselves.

Consider, for example, the science of mathematics. That has now developed into so many branches that it demands not only a high order of intellect but a formidable amount of time for its full comprehension. The pure mathematician sometimes prides himself on knowing nothing but mathematics. Certain of the famous mathematicians have been uninformed concerning branches of this science itself in which brilliant work has been done, and not to many is it given to behold, as Sylvester in picturesque language described, all separate branches of mathematics dissolving and melting into one another like the colours of a dying dolphin.

Now each one of these branches is interesting and important, and by developing all we find correspondences in them not at first suspected. But we have now reached such a point that the complete pure mathematician seldom has much energy left even for the applications of his science. He may not be even versed in mechanics. Or if he have studied mechanics he may be uninformed of the adaptation of these studies to practical needs, while of allied sciences which would be illuminated by an exposition on a good basis of mechanics, he may know nothing.[1]

If we consider now some of the treatises even of elementary mechanics, we find that the subject of algebra is often expanded into great dimensions. At this early stage then the mind is diverted by a mass of detail which is not essential to the next subjects, such as trigonometry, taken in a regular course.

[1] Even one of such lively intellect as Hermite says, in his correspondence with Stieltjes: "I am nothing but an algebrist." He adds, however, the expression of his belief that the most abstract speculations of mathematics correspond to realities, and that discoveries in analytical science arrive when it is necessary to effect some new progress in the study of quantities in the physical world.

Something would be gained if the student were carried much more rapidly to the differential calculus, so that he might obtain a clearer and wider survey of a great range of the subject with its applications. Subsequently he would return to algebra with greater power (cf. pp. 520 *et seq.*).

Also in accordance with what has already been considered, it is scientific to make all the mathematical constructions as strikingly graphic as possible. They should be exhibited, accurately constructed in some material, such as steel, that can be handled.[1]

Every process and operation should if possible be also represented graphically. This would include representations of forms of co-ordinates, of differential coefficients, of quaternion forms, and so forth. Every figure should have its essential references, as by formulæ, and other closely associated incidents, clearly and strikingly marked on it. When a figure changes into another, as, for example, an ellipse into a parabola, or a hyperbola, this should also be exhibited by means of a mechanical device, with the corresponding changes marked of the ratio of the distance of a point on the curve from the focus and from the directrix. Where surfaces of revolution are produced, these should also be exhibited in tangible form. Surfaces less regular illustrating, for example, Hamilton's exposition of the ellipsoid should be constructed with the various relations shown. Every case of the production of loci in accordance with given conditions should be exhibited in operation, and also by means of the completed form.

Every figure that can illustrate a subject should be made tangible. The most important formulæ should be displayed very conspicuously and in a striking manner

[1] Compare the brochure, "Une Question de Représentation Géométrique," by the author.

on the walls. Each subject should also be epitomised in the display of its main formulæ in succession, and with necessary indications of principle. The applications of one subject to another should also be indicated. Some of the more striking applications of certain formulæ should be expressed.

But further, whenever a surface is shown, or a formula set up, models should be exhibited of the principal ways in which applications are found, say, in engineering works, or in the investigations of science.

Such phenomena as the passage of undulations of light through crystals of various kinds should be illustrated by tangible constructions; and such a series as that involved in hearing—the concussion of the atmosphere, agitated by sound waves, on the tympanic membranes, with the communication through the ossicles to the fenestra ovalis, and thence through the auditory apparatus—should be exhibited to scale.

The teaching of mathematics should be mainly conducted in a museum, and it should borrow suggestions, in accordance with what has been expounded, from subjects such as anatomy, comparative anatomy, and modern languages.[1] Moreover, the foundations should be revised, as already here indicated, so as at once to make its meaning true, more comprehensible, and more vivid. In this manner it would be possible to teach mathematics much more rapidly and effectively than is at present the case, and to make it a more living science. Especially such a system would be of enormous use in making its capabilities of application visible and facile.

[1] In one of his famous letters to Stieltjes, Hermite says: "My dear friend, I am entirely delighted to find you in the good intent of transforming yourself into a naturalist to observe the phenomena of the world of arithmetic." He says, further, speaking of mathematical realities: "We meet with them, we discover them, we study them, like the physicists, the chemists, the zoologists." Those who do not find a profound insight in Hermite's words know only superficially mathematics—or physics, or chemistry, or zoology.

In thus enforcing what has been said regarding the science of Education, I have referred to mathematics particularly for a reason similar to that which induced me to select that science as a test of the Fundamental Processes themselves; viz. because it unites comprehensiveness of scope with precision of treatment. But with regard to the other sciences like principles apply. It should be expressly noted in reference to specialism that if a student grasp the principles of allied studies such as those of mathematics, of mechanics generally, of electrical phenomena and, say, physical chemistry, his acquisitions are not those merely of a number of different subjects, but in their combination they form a field in themselves.

We noted lately the difference of operations of a physicist and a physician, and we found that the main distinction referred to the objects of thought and to the technique. In the exposition of Reason we had occasion also to consider attentively the great importance of technique.

Referring to technique particularly, it would be possible to analyse all the combinations of movements, and their co-ordinations with tactile and other sensations, in such a way as to demonstrate them in their simplest forms. A good technical instruction should involve a training in operations devised so as to exhibit these in syntheses of increasing complexity, but devoted at each stage to some useful end. Great skill can only be obtained in some matters of technique, as we see clearly in cricket or billiards, by continual practice; but enough time could be obtained by the neglect of unimportant studies to give a grasp of the principles of technique in a variety of allied sciences, so that in subsequent study these questions of technique would neither be a complete mystery nor a complete stumbling-block.

The mental technique, that is to say, all the processes involved in the demonstration of any scientific law or in the illustration of any hypothesis, or in the obtaining of definite results by the application of theories, should also be analysed in the most complete extension; so that it can be seen on what basis they ultimately rest. But we have a means of doing this without in each case renewing the operation, for it has been in this way that the Fundamental Processes have been arrived at. Therefore what we now need is to observe simply the syntheses of these in correspondence with the development of our experiences and our thoughts.

When may Psychology be considered to have accomplished its task? Considered in its critical function Psychology will be complete when it is so thoroughly mastered as to fall into dogmatic teaching, but with its spirit interfusing and informing the whole mass of our knowledge.

The sciences, even those that have helped to the understanding of Psychology, will then be studied for themselves; but in such a manner that every experience, every phenomenon, every thought, every hypothesis, may be traced to what we know as the basis of all conscious activity—the Fundamental Processes of the mind.

But high as the leap from the exercise of the critical faculty in poetry to the true creative effort, so great is also the separation from the analytic product in Psychology to the discovery of those secrets of Nature that can be embodied in universal laws.

Milton speaks of the "Thoughts that wander through eternity," and Newton, for example, is often represented as living in a fine ether of transcendent speculation. A false impression is likely to be created by such language with regard to the actual process and means of investigation. Keats, the delicacy of whose thoughts often reveals

the true strain of the psychologist, says: "I sent my herald thought into the wilderness." Here we are much nearer to realities. Paul Heyse in his novel, "Die Kinder der Welt," mentions in describing one of his principal characters, a philosopher, his tendency to *Grübel-sucht* (brooding, or searching spirit).

The highest flights of intellect the products of which have out-distanced imagination have depended on this *Grübel-sucht*, as many instances will show. Newton was essentially a mathematician, and his discoveries are the outcome of testing in the external world the results of mathematical researches. In his mathematical work one finds a persistent searching by way of analysis for principles of development. Kepler united extraordinary patience and perseverance to a capacity for illuminated moods.

There is a deep aphorism, that cannot be too often repeated, in Graham's "Follow game." John Stuart Mill, again, said that he was always attracted by the obscure corners that had been passed over by others. In the world of physical science an obscure corner was left unnoticed for a century, for Cavendish's investigation of the constitution of air was misinterpreted by leaving out a residuum to which the great physicist had called attention. In that residuum Ramsay found new elements and incidentally filled a gap in Mendelejeff's scale.

In the chapter on research in science we have seen the value of imagination in the framing of good hypotheses, and we have also seen by what apparently trivial or accidental circumstances the mind of the thinker has received the suggestion that has led to a great discovery. But it must be understood that, as Pasteur pointed out, it is only the mind that has been prepared by a long course of patient thought that can understand the significance of these accidental experiences. An accident may supply the link to an electric circuit.

Certainly it will never be possible to demonstrate a complete system of discovery; but though we cannot exhibit the fly before it is caught, we may be able to find guidance for the spreading of the web which it is destined to encounter.

Or again, if our tentative efforts be like the fishing for intellectual trout, we may be able to gain suggestions as to the stretches of water which are favourable and as to the best way of casting the line. Particularly we may be advised what to avoid. In all sciences there are well-ascertained principles that lie at the threshold; acquaintance with these cuts sheer away whole regions of useless effort. In the selection of necessary roads and regions and in the needful instruction, we may be similarly advised to avoid those based upon, or leading up to, conventional errors.

The principle of Generalisation should be regarded as the very manner of thought. With this will be found a desire to dig deeper to foundations in order to get the broadest base for building up to particulars. But all this toil should not be formal or dry. The true scientist finds zest, spirit, curiosity, and at times intense delight in his work. We find again: the thinker's tools are the pick and the lamp. Neither suffices without the other.

The moods of inspiration, or of highly augmented efficiency of thought, should form the subject of especial study in Psychology. We are here far from the formal output of the syllogistic manner, but we are nearer to the principles of development of the mind. The suggestions that will arise from this latest discussion are so numerous and important that they would carry us beyond the scope of this work. The whole subject will doubtless some day receive a systematic investigation, and then our critical Psychology will be found to have a base for that coming glory of science, the Psychology of Research.

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Printed by Hazell, Watson & Viney, Ld., London and Aylesbury.